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PUBLIC VERSION

May 1, 2018

VIA HAND DELIVERY

Joel H. Peck, Clerk
Document Control Center
State Corporation Commission
1300 E. Main St., Tyler Bldg., 1st Floor
Richmond, Virginia 23219

Petition of Virginia Electric and Power Company For approval to implement new and continue existing demand-side management programs and for approval of two updated rate adjustment clauses pursuant to § 56-585.1 A 5 of the Code of Virginia
Case No. PUE-2016-00111

Dear Mr. Peck:

Enclosed for filing in the above-referenced proceeding are an unbound original and one (1) copy of the public (redacted) version of Virginia Electric and Power Company's May 1, 2018 Evaluation, Measurement & Verification Report prepared by DNV GL (Volumes 1-4). An extraordinarily sensitive version of this filing is also being made under seal under separate cover.

Thank you for your attention to this matter.

Highest regards,

Vishwa B. Link

enc.

cc: Service List

CERTIFICATE OF SERVICE

I hereby certify that a true copy of the extraordinarily sensitive version filed in Case No. PUE-2016-00111 was sent via U.S. mail on this 1st day of May, 2018, to the following:

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DNV·GL

Evaluation, Measurement, and Verification Report for Virginia Electric and Power Company (Dominion)

Case No. PUE-2016-00111 (Virginia)
Docket No.: E-22 Sub 545 (North Carolina)

VOLUME 1 OF 4
PUBLIC VERSION

Prepared by DNV GL (KEMA, Inc.)

Date: May 1, 2018

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1 EXECUTIVE SUMMARY

The purpose of this report is to present performance indicators of Virginia Electric and Power Company's (Dominion Energy, or the Company) demand-side management (DSM) programs and to comply with the Virginia State Corporation Commission (SCC) Order to Virginia Electric and Power Company[1] issued on March 24, 2010 ("the Order") in Case PUE-2009-00081, as later modified, to provide a detailed evaluation, measurement, and verification (EM&V) report on an annual basis.[2] In addition, this report presents performance indicators of Dominion's North Carolina DSM and Energy Efficiency (EE) programs from program launch (mid-2011) through December 31, 2017, in accordance with the North Carolina Utilities Commission's (NCUC) Orders approving DSM and EE programs in North Carolina, as well as the NCUC's subsequent direction regarding the filing of EM&V plans in North Carolina through its Orders issued in Docket No. E-22, Sub 473; and finally the NCUC's instruction to align its EM&V filing schedule with that in Virginia, annually on April 1 of each year (Docket No. E-22, Sub 524). This report is being filed on May 1, 2018 pursuant to a permanent extension granted by the SCC in Case No. PUR-2017-00129 on March 8, 2018.

This EM&V report, prepared by DNV GL Energy (DNV GL), focuses on DSM program impacts, and covers program activity through December 31, 2017. It includes Virginia and North Carolina DSM Phases I through VI programs, including a Phase VI program that launched in Virginia in late 2017.

1.1 Summary of Energy Efficiency Programs

This section presents key indicators of progress to date for the following EE programs:

- Residential Heat Pump Upgrade (DSM Phase II in Virginia and North Carolina)
- Residential Heat Pump Tune-Up (DSM Phase II in Virginia and North Carolina)
- Residential Duct Sealing (DSM Phase II in Virginia and North Carolina)
- Residential Home Energy Check-Up (DSM Phase II in Virginia and North Carolina)
- Residential Income and Age Qualifying Home Improvement (DSM Phase IV in Virginia and North Carolina)
- Residential Appliance Recycling (DSM Phase IV in Virginia)
- Residential Retail LED Lighting (DSM Phase V in North Carolina)
- Non-residential Duct Testing and Sealing (DSM Phase II in Virginia and North Carolina)
- Non-residential Energy Audit (DSM Phase II in Virginia and North Carolina)
- Non-residential Lighting Systems & Controls (DSM Phase III in Virginia and North Carolina)
- Non-residential Heating & Cooling Efficiency (DSM Phase III in Virginia and North Carolina)
- Non-residential Window Film (DSM Phase III in Virginia and North Carolina)
- Non-residential Small Business Improvement (DSM Phase V in Virginia and North Carolina)
- Non-residential Prescriptive (DSM Phase VI in Virginia and North Carolina)

The key metrics for tracking EM&V indicators of program progress are the following:

- Expenditures

[1] Hereinafter, Virginia Electric and Power Company will be referred to as "Dominion Energy" or "Company" and may also include North Carolina operations depending on the context.

[2] It is also intended to meet the EM&V reporting requirements as ordered by the SCC in Case No. PUR-2017-000047 (issued on November 9, 2017) for newly-approved DSM programs or renewals of existing DSM programs since November 9, 2017. However, this report does not include any programs that were approved in Virginia after November 9, 2017.

- Gross participation—or the total number of participants served through the program
- Net installed annualized energy savings in kilowatt hours per year (kWh/year) which is the amount of annual energy savings delivered by the program after accounting for annual savings that would have occurred in the absence of the program

Key EM&V performance indicators for EE programs (spending, participation, annualized incremental net energy savings, and net demand reductions) are shown in Table 1-1 for Virginia and Table 1-2 for North Carolina, as well as the months of participation from program launch through December 31, 2017. A few of the major highlights of these programs are listed:

- This is the last EM&V report where the DSM Phase II programs will be reported in the main sections of the report. In future annual reports, these programs will be reported in the closed programs section because they have retired as designed. They were available to customers in Virginia for approximately five years, and customers in North Carolina for approximately three-and-a-half years.
- Of the residential EE direct installation programs, the Residential Income and Age Qualifying Home Improvement program (DSM Phase IV) is the only program that was available to customers for the entire 2017 program year. This program exceeded net annualized energy savings targets in both Virginia and North Carolina at 254% and 146%, respectively. Participation exceeded the program's planned target in Virginia at 155%, but was below target at 56% in North Carolina.
- In its second year in Virginia, the Non-residential Small Business Improvement (DSM Phase V) exceeded both participation and net annualized energy savings targets at 118% and 256%, respectively. This was achieved at 59% of the target total spending for this program. This was the first year that the program was implemented in North Carolina. As is the case for most programs that DNV GL has tracked and evaluated for the Company, the first year typically does not achieve target participation or energy targets because the program is ramping up and building its contractor network. Participation in North Carolina in 2017 was 17% of target and net annualized energy savings was 54% of target.
- The Non-residential Lighting Systems and Controls program continues to exceed net annualized energy-savings targets in Virginia at 139% from 2014-2017. Participation in Virginia was at 65% of target over the same period. In North Carolina, from 2015-2017 the program achieved 71% of net annualized energy savings target and 26% of participation target.

Cumulative participation, net energy savings, and net demand reductions for each program are provided in Appendices C and D. Those values are used as inputs for integrated resource planning, lost revenue recovery (if pursued), program performance incentives, and other calculations requiring cumulative net energy savings over time for each program.

Table 1-1. Annualized Program Progress for Energy Efficiency Programs (Cumulative from Program Start through December 31, 2017) in Virginia

Program	Expenditures	Gross Participants	Net Energy Savings kWh/year	Months Since First Participation
Residential Programs				
Residential Heat Pump Upgrade - Virginia (DSM II)				
Actual	[redacted]	17,784	13,477,128	63
Planned (Year End Total)	[redacted]	56,578	44,196,174	

Program	Expenditures	Gross Participants	Net Energy Savings kWh/year	Months Since First Participation
Cumulative % Toward Plan	45%	31%	30%	
Residential Heat Pump Tune Up – Virginia (DSM II)				
Actual	[redacted]	87,126	18,609,439	63
Planned (Year End Total)	[redacted]	145,577	93,176,895	
Cumulative % Toward Plan	62%	60%	20%	
Residential Duct Sealing – Virginia (DSM II)				
Actual	[redacted]	3,299	764,592	63
Planned (Year End Total)		16,720	7,662,081	
Cumulative % Toward Plan	58%	20%	10%	
Residential Home Energy Check Up – Virginia (DSM II)				
Actual	[redacted]	51,914	32,619,381	63
Planned (Year End Total)	[redacted]	9,488	11,328,552	
Cumulative % Toward Plan	269%	547%	288%	
Residential Income and Age Qualifying Home Improvement – Virginia (DSM IV)				
Actual	[redacted]	5,970	1,945,390	27
Planned (Year End Total)	[redacted]	3,846	765,945	
Cumulative % Toward Plan	109%	155%	254%	
Residential Appliance Recycling – Virginia (DSM IV)				
Actual	[redacted]	14,072	10,923,914	28
Planned (Year End Total)	[redacted]	14,250	11,647,008	
Cumulative % Toward Plan	96%	99%	94%	
Non-residential Programs				
Non-residential Duct Testing and Sealing – Virginia (DSM II)				
Actual	[redacted]	4,444	68,840,057	62
Planned (YE Total)	[redacted]	1,933	46,722,290	
Cumulative % Toward Plan	108%	230%	147%	
Non-residential Energy Audit – Virginia (DSM II)				
Actual	[redacted]	1,632	39,138,178	61
Planned (YE Total)	[redacted]	2,410	52,159,321	
Cumulative % Toward Plan	124%	68%	75%	
Non-residential Lighting Systems and Controls – Virginia (DSM III)				
Actual	[redacted]	3,430	134,735,543	39
Planned (YE Total)	[redacted]	5,276	97,112,026	
Cumulative % Toward Plan	126%	65%	139%	
Non-residential Heating and Cooling Efficiency – Virginia (DSM III)				

Program	Expenditures	Gross Participants	Net Energy Savings kWh/year	Months Since First Participation
Actual	[redacted]	312	23,632,707	
Planned (YE Total)	[redacted]	2,586	75,204,654	38
Cumulative % Toward Plan	70%	12%	31%	
Non-residential Window Film – Virginia (DSM III)[3]				
Actual	[redacted]	439,004	5,143,800	
Planned (YE Total)	[redacted]	3,333,400	33,459,821	39
Cumulative % Toward Plan	32%	13%	15%	
Non-residential Small Business Improvement – Virginia (DSM V)				
Actual	[redacted]	1,004	14,280,899	
Planned (YE Total)	[redacted]	851	5,579,025	15
Cumulative % Toward Plan	59%	118%	256%	
Non-residential Prescriptive – Virginia (DSM VI)				
Actual	[redacted]	4	594	
Planned (YE Total)	[redacted]	266	5,959,948	15
Cumulative % Toward Plan	20%	2%	0%	
[redacted]				
Actual	[redacted]	190,991	364,111,623	
Planned (YE Total)	[redacted]	259,781	484,973,738	
Cumulative % Toward Plan	88%	74%	75%	

When reviewing the North Carolina results shown in Table 1-2, it is important to note that the NC programs are operated under a cost allocation formula as a subset of the overall system-level program budget. The allocation is approximately 6% NC and 94% VA. This necessitates that Dominion carefully manage the NC programs so as to not exceed the allocation.

It is also worth noting that the SCC has approved existing DSM program budgets by DSM phases and by the residential and non-residential program categories. This allows the Company the discretion to allocate spending among the various programs as appropriate, while managing spending against the overall approved total budget.

Table 1-2. Annualized Program Progress for Energy Efficiency Programs (Cumulative from Program Start through December 31, 2017) in North Carolina

Program	Expenditures	Gross Participants	Net Energy Savings kWh/year	Months Since First Participation
Residential Programs				

[3] Non-Residential Window Film program participation value is in square feet rather than participant count.

[4] Excludes Non-Residential Window Film participation values because it is measured in square feet rather than participant count.

Program	Expenditures	Gross Participants	Net Energy Savings kWh/year	Months Since First Participation
Residential Heat Pump Upgrade – North Carolina (DSM II)				
Actual	[redacted]	1,424	297,685	
Planned (Year End Total)	[redacted]	2,652	2,125,858	43
Cumulative % Toward Plan	55%	54%	14%	
Residential Heat Pump Tune Up – North Carolina (DSM II)				
Actual	[redacted]	5,287	1,208,206	
Planned (Year End Total)	[redacted]	7,096	4,406,474	44
Cumulative % Toward Plan	61%	75%	27%	
Residential Duct Sealing – North Carolina (DSM II)				
Actual	[redacted]	554	133,828	
Planned (Year End Total)	[redacted]	793	374,621	36
Cumulative % Toward Plan	78%	70%	36%	
Residential Home Energy Check Up – North Carolina (DSM II)				
Actual	[redacted]	1,049	791,659	
Planned (Year End Total)	[redacted]	1,201	633,976	36
Cumulative % Toward Plan	123%	87%	125%	
Residential Income and Age Qualifying Home Improvement – North Carolina (DSM IV)				
Actual	[redacted]	287	172,939	
Planned (Year End Total)	[redacted]	511	118,239	18
Cumulative % Toward Plan	89%	56%	146%	
Residential Upstream LED Lighting – North Carolina (DSM V)[5]				
Actual	[redacted]	70,261	2,371,259	
Planned (Year End Total)	[redacted]	165,000	2,250,789	18
Cumulative % Toward Plan	61%	43%	105%	
Non-residential Programs				
Non-residential Duct Testing and Sealing – North Carolina (DSM II)				
Actual	[redacted]	250	3,155,166	
Planned (YE Total)	[redacted]	99	2,209,754	39
Cumulative % Toward Plan	123%	253%	143%	
Non-residential Energy Audit – North Carolina (DSM II)				
Actual	[redacted]	108	1,386,517	
Planned (YE Total)	[redacted]	122	2,243,824	39
Cumulative % Toward Plan	127%	89%	62%	
Non-residential Lighting Systems and Controls – North Carolina (DSM III)				

[5] Residential Retail LED Lighting program participation value is in lamps purchased rather than participant count.

Program	Expenditures	Gross Participants	Net Energy Savings kWh/year	Months Since First Participation
Actual	[redacted]	79	3,945,182	
Planned (YE Total)	[redacted]	302	5,593,002	33
Cumulative % Toward Plan	72%	26%	71%	
Non-residential Heating and Cooling Efficiency – North Carolina (DSM III)				
Actual	[redacted]	12	324,531	
Planned (YE Total)	[redacted]	153	4,790,614	33
Cumulative % Toward Plan	42%	8%	7%	
Non-residential Window Film – North Carolina (DSM III)[6]				
Actual	[redacted]	-	0	
Planned (YE Total)	[redacted]	216,401	2,081,597	0
Cumulative % Toward Plan	23%	0%	0%	
Non-residential Small Business Improvement – North Carolina (DSM V)				
Actual	[redacted]	7	154,851	
Planned (YE Total)	[redacted]	42	288,232	7
Cumulative % Toward Plan	28%	17%	54%	
[redacted]				
Planned (YE Total)	[redacted]	9,057	13,941,822	
Actual	[redacted]	12,971	27,116,980	
Cumulative % Toward Plan	75%	70%	51%	

At the end of 2017, the only DSM Phase I program still operating was the Residential Air Conditioner (AC) Cycling (demand response) Program in both Virginia and North Carolina. All other DSM Phase I programs closed in 2015. No new information is presented in this report for the closed Phase I programs.

DSM Phase III programs in Virginia are well into their fourth year of operation and stabilizing in terms of participant growth in North Carolina. The Non-residential Lighting Systems & Controls Program in Virginia and in DSM Phase III is exceeding targets for net annualized energy savings.

Both of the DSM Phase IV programs are retiring as planned at the end of this year, and both have ended either very near or over their net annualized energy savings targets. The Residential Income and Age Qualifying Home Improvement Program exceeded targets in both states and the Residential Appliance Recycling Program nearly achieved its targets in Virginia.

The Small Business Improvement Program, as part of DSM Phase V, is ramping up quickly. The Program became available to eligible customers in the summer of 2016, and participants began enrolling in the Program in October 2016. At the end of this year, it contributed 16% of the total Virginia DSM EE portfolio

[6] Non-Residential Window Film program participation value is in square feet rather than participant count.

[7] Excludes Non-Residential Window Film participation values because it is measured in square feet rather than participant count, and excludes Residential Retail LED Lighting participation value because it is measured in lamps purchased rather than participant count.

program net annualized energy savings in 2017, the second highest contributing program (after the Non-residential Lighting Systems & Controls program, contributing 59% of 2017 Virginia portfolio savings). On June 1, 2017, the SCC ordered (Case No. PUE 2016-00111) the Company to discontinue rebates for refrigeration measures in this program. Those customers who had already installed and applied for rebates at of the time of the order were allowed to be rebated (ordered on June 22, 2017 under the same order).

Going forward, the Small Business Improvement Program will continue without refrigeration measures. However, those measures were approved in the Non-residential Prescriptive Program (DSM Phase VI) in Case No. PUE-2016-00111. Therefore, eligible customers may still receive incentives for those cost-effective measures.

The DSM Phase II programs expired at the end of December 2016, as ordered by the SCC and NCUC. Of the DSM Phase II programs in Virginia and North Carolina, the Residential Home Energy Check-Up and Non-residential Duct Sealing Programs met or exceeded targets in both states after slightly over five years of operations in Virginia, while the remaining DSM Phase II programs did not meet their targets.

As the DSM Phase II programs were winding down at the end of 2016, Dominion announced on its website that the programs were closed to new participants in both states. The announcement further explained that to be eligible for a rebate, services must be completed by a participating contractor by December 24, 2016, and rebate applications received by February 7, 2017. Therefore, while those programs stopped enrolling new participants as of the end of 2016, DNV GL continued to receive customer data that was processed at the beginning of 2017.

The Company requested SCC approval to extend the DSM Phase II Residential Heat Pump Upgrade Program for two additional years, and the Non-residential Distributed Generation (DG) Program for five additional years (Case No. PUE-2016-00111). In the same filing, the Company also requested approval of two new DSM Phase VI programs, the Residential Home Energy Assessment Program and the Non-residential Prescriptive Program for a five-year implementation period. The SCC issued a final order on Dominion Energy's application on June 1, 2017. Of the requests, the Non-residential DG Program and the Non-residential Prescriptive Program requests were approved for five years from July 1, 2017 through June 30, 2022.

A lesson learned from reviewing the results from the DSM Phase II programs was that enrollment and energy savings achieved through a program's life varies year by year. The first and last years of a program's life are generally different than the middle years. The first partial year that a program is launched usually incurs the majority of the ramp-up costs. This cannot be used as an indicator of the program's steady-state for the remaining years. Depending on the individual program, it can take at least another full year before the program stabilizes and begins enrolling participants and achieving energy savings and demand reductions at its intended pace. The final year can also be abnormal due to the uncertainty of the program's future and close-out activities.

It is important to understand where the program is in its life-cycle as well as its place in the context of the larger market when reviewing EM&V results for indicators of program success and lessons learned in program design and implementation. These trends show that a five-year program cycle gives more insight into program performance than a three-year cycle.

Figure 1-1 shows the distribution of net annualized energy savings across the Virginia portfolio. Non-residential programs contributed significantly toward the overall portfolio's energy savings (approximately 85%), while residential programs account for about 15%.

For the 2017 calendar year, compared to the previous year, the Non-residential Duct Testing and Sealing program has retired. It has consistently been one of the programs that contributed the largest amount of net annualized energy savings. With this change, the top three performing programs by the energy savings have changed to Non-residential Lighting Systems & Controls, Non-residential Small Business Improvement, and the Residential Appliance Recycling program, in decreasing order.

Figure 1-1. Installed Net Annualized Energy Savings (kWh/year) Across the VA Energy Efficiency Program Portfolio in 2017

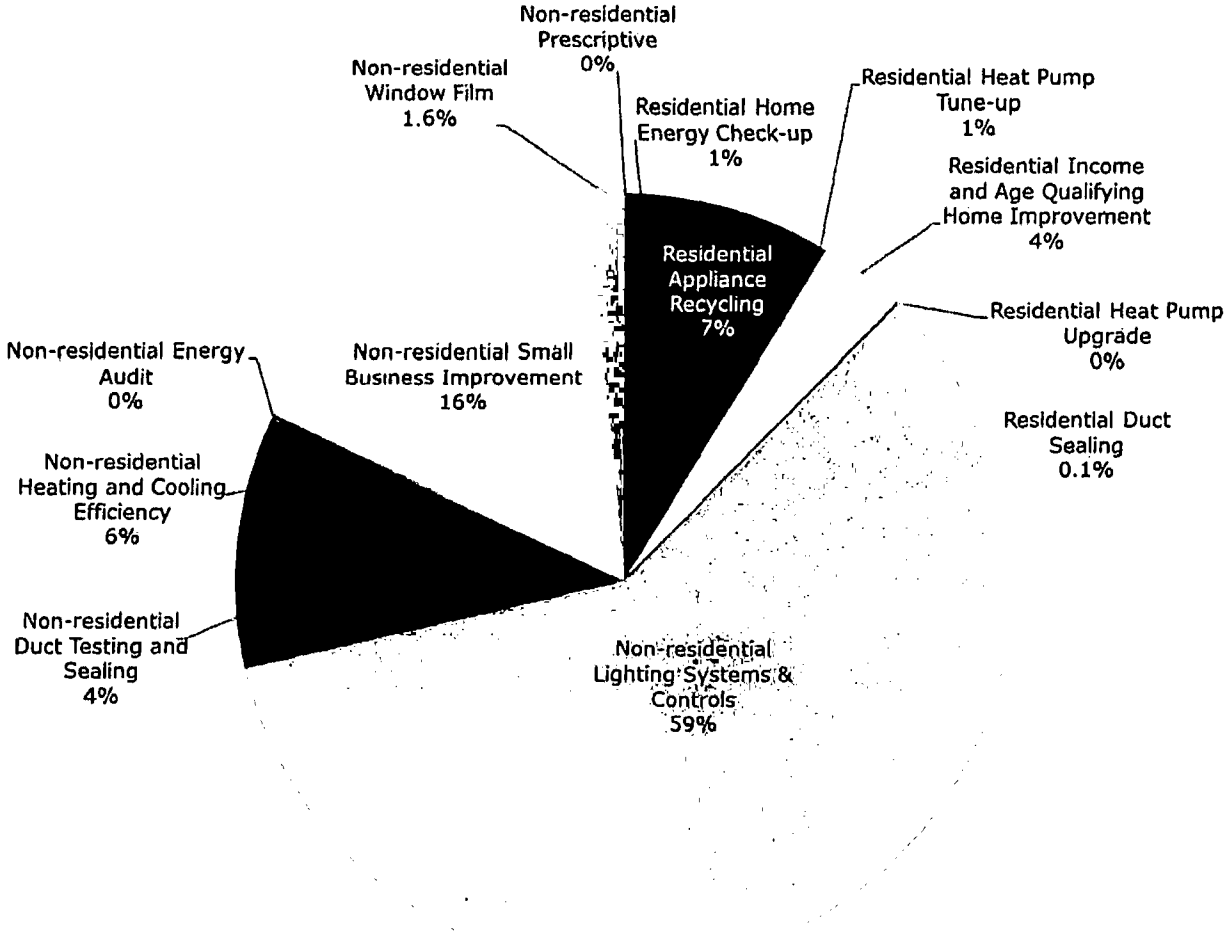
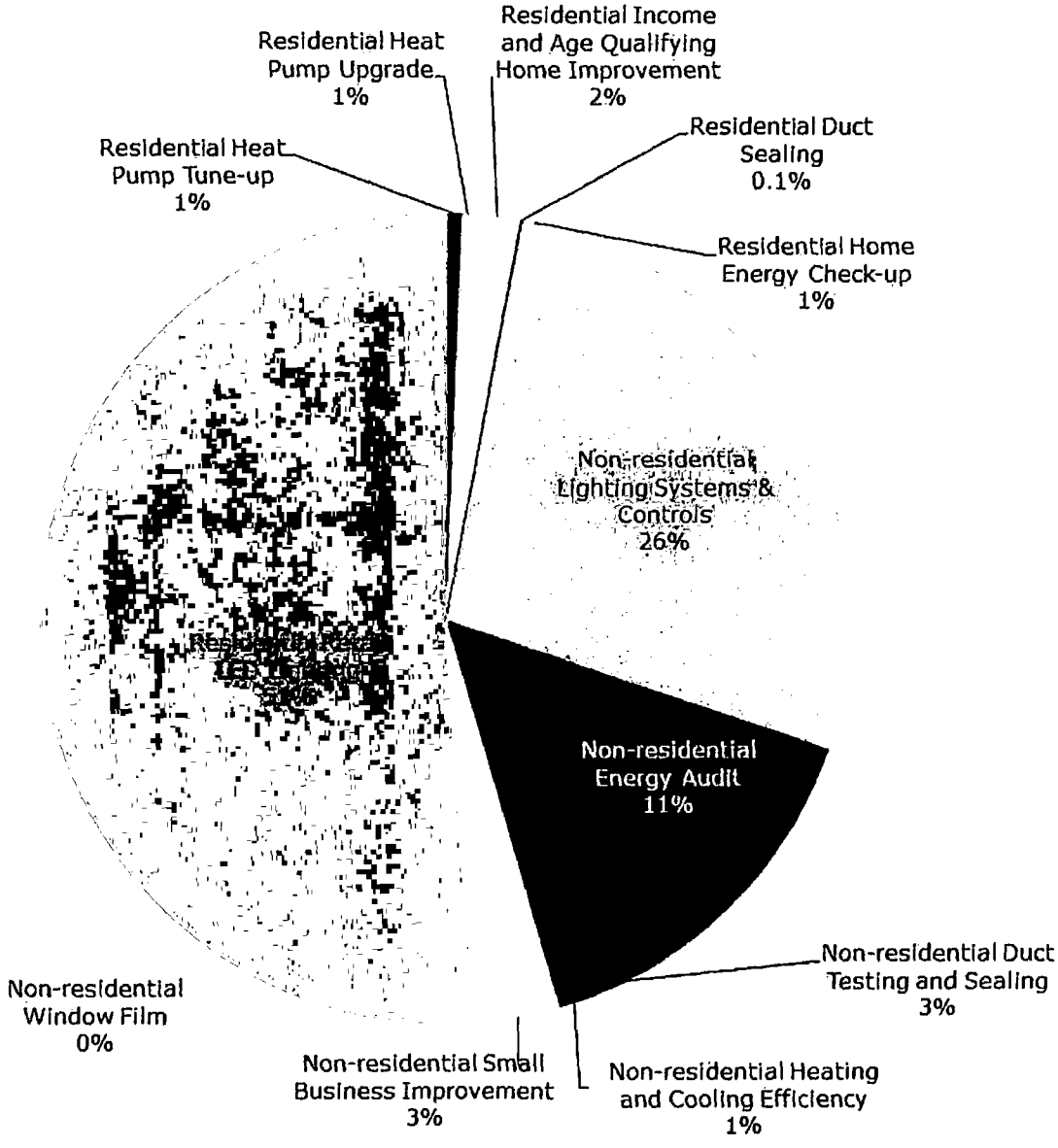


Figure 1-2 shows the distribution of net annualized energy savings across the North Carolina portfolio for the 2017 calendar year. Unlike Virginia, non-residential programs contributed to slightly less than half (49%) of

the portfolio's savings. The Residential Retail LED Lighting program contributed 51% of the savings in 2017, in its first year.

In North Carolina, the second and third highest producing programs, in terms of savings achieved were the Non-residential Lighting Systems & Controls and Non-residential Energy Audit programs.

Figure 1-2. Installed Net Annualized Energy Savings (kWh/year) Across the NC Energy Efficiency Program Portfolio in 2017



1.2 Summary of Peak Shaving Programs

The following sections present key indicators of progress to-date for two peak shaving programs, the Residential Air Conditioner (AC) Cycling (or Smart Cooling Rewards) Program and the Non-residential DG Program, offered in Virginia only. DNV GL conducted EM&V impact evaluations for both programs (provided in Appendices O-1 and P-1).

The key metrics for evaluating program impacts are the following:

- Expenditures
- Net participation
- Net peak shaving potential in kilowatts (kW)

Key EM&V performance indicators for peak shaving programs are shown in Table 1-3.

Table 1-3. Portfolio Spending and Net Peak Shaving Potential by Program (Cumulative through December 31, 2017)

Program	Expenditures	Number of Participants	Peak Shaving Potential kW	Months Since First Participation
Residential AC Cycling—Virginia				
Actual	[redacted]	88,845	60,414	91
Planned (Year End Total)	[redacted]	97,037	95,027	
Cumulative % Toward Plan	77%	92%	64%	
Residential AC Cycling—North Carolina				
Actual	[redacted]	3,598	2,447	77
Planned (Year End Total)	[redacted]	5,963	5,392	
Cumulative % Toward Plan	63%	74%	45%	
Non-residential Distributed Generation—Virginia				
Actual	[redacted]	6	5,992	72
Planned (Year End Total)	[redacted]	7	7,394	
Cumulative % Toward Plan	43%	82%	81%	
Total				
Actual	[redacted]	-	70,706	[redacted]
Planned (Year End Total)	[redacted]	-	107,813	
Cumulative % Toward Plan	73%	-	66%	

In terms of planning, most of the peak shaving potential (88%) was expected from the Residential AC Cycling program in Virginia (95,027 kW out of 107,813 kW) in 2017. The AC Cycling program reached 92% of its planned participation goal and 64% of its cumulative peak shaving potential in Virginia. North Carolina reached 74% of its planned participation goal and 45% of its cumulative peak shaving potential. Program expenditures in 2017 were 77% of the plan for Virginia and 63% for North Carolina.

The Non-residential DG Program achieved 82% of planned participation and 81% of planned peak shaving potential.

1.3 Summary of Closed Programs

The Residential Lighting, Commercial Lighting, Commercial HVAC, and Residential Low-Income Programs, all part of DSM Phase I, are closed in Virginia and North Carolina. The Residential Lighting Program concluded on December 31, 2011. In its April 30, 2012 Order in PUE-2011-00093, the SCC denied approval of the requested additional funding for the Commercial Lighting and Commercial HVAC Upgrade Programs. Consistent with the SCC's Order, the Company began winding down these Programs, with the Programs ending on July 31, 2012.

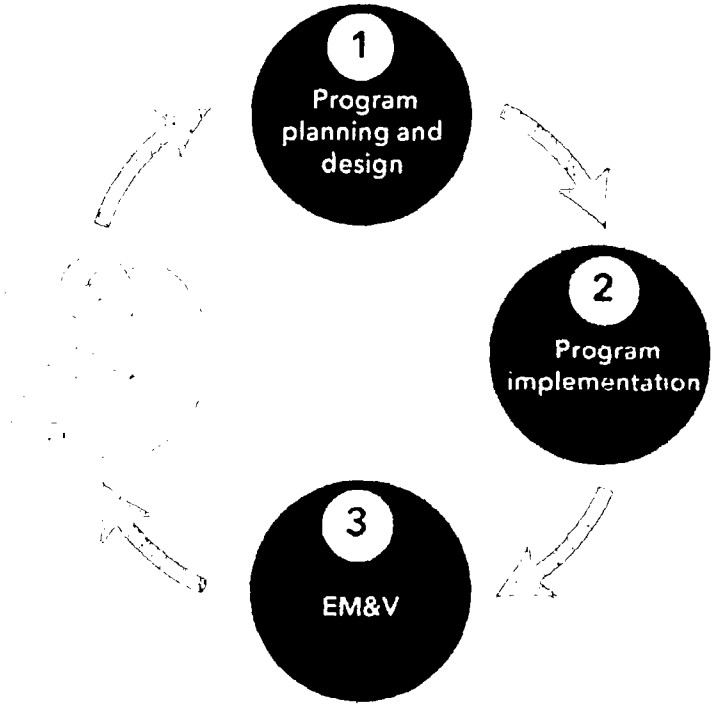
The NCUC granted the Company's request in Docket Nos. E-22, Subs 467 and 479 to suspend the Commercial HVAC and Commercial Lighting Programs on August 14, 2012, and allowed the Programs to be assessed for program cost-effectiveness in North Carolina only. Both Programs were found to be cost-effective in North Carolina, and the Company subsequently re-filed for approval on August 20, 2013. The Programs were active in North Carolina throughout 2014, with a closing date of December 31, 2014. The two programs were reintroduced in 2015 through the newly proposed and redesigned DSM Phase III programs in the form of the Non-residential Heating and Cooling Efficiency Program and Non-residential Lighting Systems & Controls Program, which were approved in Docket Nos. E-22, Subs. 507 and 508, respectively.

The DSM Phase I Residential Low-income Program closed in North Carolina at the end of 2015 (Docket E-22, Sub 463 Order on September 9, 2014). The Program has been replaced by the DSM Phase IV Residential Income and Age Qualifying Home Improvement Program (Docket E-22, Sub 523), which was approved by the NCUC on October 6, 2015. This program was designed to close at the end of 2017. On December 6, 2017, the program was suspended by the NCUC in Docket No. E-22, Sub 523 at Dominion Energy's request. On October 3, 2017, the Company requested a program extension in Virginia (Case No. PUR-2017-00129) and is awaiting the SCC's decision. Dominion's EE program portfolio is designed to be managed and operated as a consolidated, system-wide basis in both Virginia and North Carolina, to minimize program costs and optimize deployment. Since the program will expire in Virginia in early 2018, Dominion Energy requested the suspension and program renewal at a future date pending program approval in Virginia in the previously mentioned case. See Table 2-1 for a summary of the program approval, suspension, and closure activities.

1.4 Study Approach

EM&V is an important part of a program's cycle because it can produce findings that are utilized during the program planning and design stage, allowing for continuous improvement as the program evolves, as illustrated in Figure 1-3.

Figure 1-3. Illustration of a program cycle



EM&V reports typically review and report on available program data that has been collected and validated, collect and report data from secondary or primary research activities, and offer recommendations for improvements to specific program designs where applicable. EM&V direct-measurement data can also be, and has been in previous years, integrated into Dominion's long-term system planning process through the incorporation of more current data into its future Integrated Resource Plan (IRP) modeling when appropriate.

This EM&V report is organized by the following sections:

- Review and assessment of program tracking data for the entire program period of performance since May 1, 2010 (Appendices A, B, C, and D)
  - Appendices A and B show screenshots of the program performance indicator table results for each of Dominion's Virginia and North Carolina DSM active and closed programs from program inception to the end of 2017. Appendix A shows the Virginia performance indicator tables and Appendix B shows the North Carolina tables. Abbreviated version of these tables for the current year are also included in the main body of this report, in each program's report section. They show the year-end program spending, participation, gross and net annualized energy savings and demand reductions compared against planning goals for the year.
  - Appendix C and D show screenshots of the summary tables used for claiming lost revenue, program performance incentives, IRP modeling, and other purposes used in both states. Appendix C shows gross energy savings and demand reductions. Appendix D shows net energy

savings and demand reductions. They are not referenced in the main body of the report, other than in this section.

- EM&V Plans for each active program for the following year, 2018 (Appendices G through P)
- Impact analysis of the 2017 AC Cycling Program event season to assess the load reductions from a sample of participants, which in 2017 included all participants with advanced metering infrastructure (AMI) meters (Appendix O-1)
- Impact analysis of the 2017 event season for the Non-residential Distributed Generation Program (Appendix P-1)

2 INTRODUCTION

This report presents performance indicators of Dominion Energy's DSM programs in Virginia and North Carolina.

In Virginia, it is in compliance with the SCC's Order requiring detailed EM&V reports following DSM program implementation, which states:

> *Furthermore, we conclude that the DSM Programs approved herein are in the public interest subject to the following requirements ... Third, the Company shall file detailed* [Measurement & Verification] *M&V reports in this proceeding, with service on Staff and all parties to this case, every six months beginning October 1, 2010.*
>
> *Finally, Virginia Power shall implement its commitment, as discussed during the hearing, to coordinate with the participants in this case and other interested parties in evaluating the M&V results and in developing further DSM Program proposals. For example, if the M&V data establishes that a program is not performing as expected, the Company and the participants to this case should address modifications to, or removal of, such program. These M&V reports, among other things, will provide significant information for purposes of subsequent evaluations as to whether certain programs warrant continuation thereof. Accordingly, we find that the M&V reports should be filed in this DSM proceeding.*[8]

In its Order of April 30, 2012, the SCC approved the Company's request to issue annual EM&V Reports on April 1, focusing on DSM program impacts from the previous calendar year. Again, the SCC granted a motion in Case No. PUR-2017-00129 to extend the filing date for this 2018 and all future EM&V Report to May 1 of each year.[9] As required by the 2010 Order, the Company and DNV GL reviewed prior EM&V Reports with interested stakeholders at the annual Stakeholder Review Process meetings, the most recent of which was September 20, 2017.[10]

On September 1, 2010, Dominion Energy filed an application for the NCUC's approval of six DSM programs. On February 22, 2011, NCUC approved the same five DSM Phase I programs that were approved in Virginia. As a condition of approval, EM&V reports must be filed with the NCUC, which are to include the EM&V reports filed in Virginia, as well as information specific to the Company's North Carolina customers. The NCUC subsequently directed Dominion Energy to revise its annual EM&V reporting cycle to April 1 each year, which was then extended to May 1 consistent with the Virginia deadline.[11]

The SCC issued its order regarding new rules governing the EM&V of the effects of utility-sponsored DSM programs (Case No. PUR-2017-00047) on November 9, 2017. The new rules apply prospectively to new or renewing DSM programs starting from the order date. As of this EM&V report, there have been no new or renewing DSM programs that have been approved. Should the above mentioned DSM Phase IV Residential

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[8] *Virginia Electric and Power Company Petition for approval to implement new DSM programs and for approval of two rate adjustment clauses pursuant to 56-585.1 A 5 of the Code of Virginia*, Case No. PUE-2009-00081, Order Approving Demand Side Management Programs at 12 (March 24, 2010).

[9] *Virginia Electric and Power Company Petition for approval to extend an existing DSM program and for approval of two updated rate adjustment clauses pursuant to § 56-585.1 A 5 of the Code of Virginia*, Case No. PUR-2017-00129, Order Granting Motion (March 8, 2018).

[10] Previous stakeholder meetings DNV GL attended were October 6, 2010, February 24, 2011, October 20, 2011, October 19, 2012, October 24, 2013, November 3, 2014, September 8, 2015, and September 6, 2016.

[11] *In the Matter of Application of Virginia Electric and Power Company d/b/a Dominion North Carolina Power, for Approval of Demand Side Management and Energy Efficiency Cost Recovery Rider Pursuant to G.S. 62-133.9 and Commission Rule R8-69*, Order Approving DSM/EE Rider and Requiring Customer Notice at 13, Docket No. E-22, Sub 473 (December 13, 2011).

Income and Age Qualifying Home Improvement Program be renewed by the SCC, it will be the first Dominion Energy program to which these new rules apply in 2018.

2.1 Programs Covered in This Report

This report covers eight active and ongoing DSM programs, seven programs that were retired as planned in 2017, and four programs that have been closed in Virginia since before 2017. The report also covers seven active and ongoing DSM programs, six programs that were retired as planned in 2017, and four programs that have been closed in North Carolina since before 2017. This report divides the DSM programs into four categories:

- EE programs – residential
- EE programs – non-residential
- Peak shaving programs
- Closed programs

Table 2-1 shows the specific programs included in this report and the SCC's or NCUC's Order Date for approval, suspension, reinstatement, and closure of each of these programs. It also shows updated key program values as a result of EM&V efforts conducted in 2017 and the average annualized kWh/year per participant before and after the update. The change in the average annualized kWh/year per participant values are a function of the following:

- Updates to adjustment factors or values based on EM&V activities
- Updates to deemed savings calculation methodology based on regular Standard Tracking and Engineering Protocol Manual (STEP Manual) updates
- Variation in participant characteristics as inputs to the deemed savings calculations from year to year

Note that changes in deemed savings methods approaches that also drive changes in average participant values are not detailed here, but rather in Appendix F, STEP Manual.

Sections 2.1.1 through 2.1.4 give brief descriptions of all programs covered in this report.

Table 2-1. Categories and list of 2017 DSM programs in this report

Program	State	Date of Order	EM&V Update Description[12]	Updated Factor/ Value Source	Effec-tive Date	Previous Factor/ Value	Updated Factor/ Value	Updated Participant kWh/year
Energy Efficiency—Residential								
Residential Appliance Recycling	VA	April 24, 2015	None					
Residential Duct Sealing[13]	VA	April 30, 2012	None					
	NC	December 16, 2013	None					
Residential Heat Pump Upgrade	VA	April 30, 2012	None					
	NC	December 17, 2013	None					
Residential Heat Pump Tune-Up	VA	April 30, 2012	None					
	NC	December 17, 2013	None					
Residential Home Energy Check-Up	VA	April 24, 2015	None					
	NC	December 17, 2013	None					
Residential Income and Age Qualifying Home Improvement	VA	April 24, 2015	None					
	NC	October 6, 2015	None					
Residential Retail LED Lighting	NC	December 20, 2016	None					
Energy Efficiency—Non-residential								
Non-residential Duct Testing and Sealing	VA	April 30, 2012	None					
	NC	December 17, 2013	None					
Non-residential Energy Audit	VA	April 30, 2012 Enhancements: April 29, 2014	None					
	NC	December 16, 2013						
Non-residential Heating & Cooling Efficiency	VA	April 29, 2014	None					
	NC	October 27, 2014	None					
Non-residential Lighting Systems & Controls	VA	April 29, 2014	None					
	NC	October 27, 2014	None					
Non-residential Prescriptive	VA	June 1, 2017	None					

[12] Changes to participant kWh/year are also partially driven by updates to the deemed annualized savings methodology as a result of regular updates made to the STEP Manual. To review those specific updates, refer to Appendix F.

[13] The Residential Duct Testing and Sealing Program was renamed as the Residential Duct Sealing Program.

Program	State	Date of Order	EM&V Update Description[12]	Updated Factor/ Value Source	Effec-tive Date	Previous Factor/ Value	Updated Factor/ Value	Updated Participant kWh/year
	NC	October 16, 2017						
Non-residential Small Business Improvement	VA	April 19, 2016	None					
	NC	October 26, 2016	None					
Non-residential Window Film	VA	April 29, 2014	None					
	NC	October 27, 2014	None					
Peak Shaving Programs								
Residential AC Cycling	VA	March 24, 2010	Operability rate	Operability rate	2017	N/A	N/A	kW/ participant
		April 19, 2016	Opt-out rate	Opt-out rate	2017	0.36%	0.03%	
			Removal/ deactivation rate	Removal/ deactivation rate	2017	-1.05%	-0.92%	
	NC	February 22, 2011	Operability rate	Operability rate	2017	N/A	N/A	
			Opt-out rate	Opt-out rate	2017	0.36%	0.03%	
			Removal/ deactivation rate	Removal/ deactivation rate	2017	0.94%	0.33%	
Non-residential Distributed Generation	VA	April 30, 2012 June 1, 2017	None					

2.1.1 Energy Efficiency Programs – Residential

All but two of the seven residential programs listed below are offered in both Virginia and North Carolina. The programs that are not offered in both states currently are the Residential Appliance Recycling Program, which is offered in Virginia only, and the Residential Retail LED program, which is offered in North Carolina only.

In 2016, Dominion Energy announced that the DSM Phase II programs were closed to new participants in both states since the programs have reached their program approval end date as approved in Case No. PUE-2011-00093. In order to be eligible for a rebate, the service must have been completed by a participating contractor by December 24, 2016. The announcement also stated that rebate applications must be received by February 7, 2017. These programs include the Residential Heat Pump Upgrade, Residential Heat Pump Tune-Up, Residential Duct Sealing, and Residential Home Energy Check-Up Programs. Dominion Energy filed for an extension of the Residential Heat Pump Upgrade Program in Case No. PUE-2016-00111, which was not approved.[14] The following are the 2017 programs evaluated in this report:

- Residential Heat Pump Upgrade: This program provides incentives for residential heat pump (e.g., air and geothermal) upgrades to residential homeowners who may be interested in installing a new, higher efficiency, ENERGY STAR®-rated heat pump unit.
- Residential Heat Pump Tune-Up: This program provides qualifying residential homeowners with an incentive to have a contractor tune-up their existing heat pumps once every five years in order to achieve maximum operating performance.
- Residential Duct Sealing: This program promotes the repair of poorly performing duct- and air-distribution systems in residential homes. Qualifying customers with a heat pump receive an incentive for having a contractor seal ducts in their homes using program-approved methods and eligibility paths.
- Residential Home Energy Check-Up: This program provides owners and occupants of single-family homes and townhomes an easy and low-cost home energy walk-through audit, which includes the direct installation of some energy saving measures and recommendations for additional home energy improvements.
- Residential Income and Age Qualifying Home Improvement: This program is the updated version of the Residential Low-Income Program from DSM Phase I. It provides low-income and age qualifying homeowners with a free energy check-up that identifies and installs energy conservation measures within their residences to help save energy.
- Residential Appliance Recycling (Virginia): This program provides qualifying residential customers in the Company's Virginia service territory with an incentive to recycle their existing and operating refrigerators and freezers.
- Residential Retail LED Lighting (North Carolina): This program provides residential customers in the Company's North Carolina service territory with an instant discount for qualifying light-emitting diode (LED) light bulb purchases from a participating retailer.

2.1.2 Energy Efficiency Programs – Non-residential

Each non-residential energy efficiency program below is offered in both Virginia and North Carolina. The Non-residential Prescriptive Program was approved for implementation in North Carolina in Docket No E-22, Sub 543, by order dated October 16, 2017 and was launched in the Company's NC service territory in

[14] Case PUE-2016-00111. Order date: June 1, 2017.

January 2018. Dominion Energy announced that the Company's DSM Phase II non-residential and residential programs were closing to new participants in both states, and that to be eligible for a rebate, the service must have been completed by a participating contractor by December 24, 2016. The announcement further stated that rebate applications must be received by February 7, 2017. These recently closed DSM Phase II non-residential programs include the Non-residential Duct Testing and Sealing and the Non-residential Energy Audit Programs.

The following list consists of all 2017 non-residential programs that were evaluated in this report:

- Non-residential Duct Testing and Sealing: This program promotes testing and general repair of poorly performing duct and air distribution systems in non-residential facilities. The program provides incentives to qualifying customers who have a contractor seal ducts in existing buildings using program-approved methods.
- Non-residential Energy Audit: This program provides qualifying customers with an on-site energy audit by a contractor in Dominion Energy's contractor network in non-residential facilities. Customers receive a rebate once they provide documentation that recommended EE improvements have been made.
- Non-residential Lighting Systems & Controls: This program provides non-residential customers with an incentive to retrofit their existing inefficient lighting system with a more cost-effective, energy efficient lighting system.
- Non-residential Heating and Cooling Efficiency: This program provides incentives to non-residential customers to upgrade existing heating or cooling equipment or install new energy efficient technologies.
- Non-residential Window Film: This program provides incentives to non-residential customers to install window film to reduce energy consumption and peak demand during the cooling season.
- Non-residential Small Business Improvement: This program provides small business customers with on-site energy assessments of their facilities and incentives for direct install lighting, duct testing and sealing, HVAC upgrades, and prescriptive re-commissioning through participating contractors.
- Non-residential Prescriptive: This program provides incentives to qualifying non-residential customers for cooking, refrigeration, and HVAC measures installed through participating contractors.

2.1.3 Peak Shaving Programs

Dominion Energy operates two peak shaving programs—the AC Cycling Program and the Non-residential DG Program. The Residential AC Cycling program is offered in Virginia and North Carolina. The Non-residential DG Program is offered in Virginia only.

- Residential AC Cycling: Marketed as the Smart Cooling Rewards Program, customers in the Residential AC Cycling Program are compensated with a $40 bill credit in the December billing cycle in exchange for allowing Dominion Energy to reduce the operating cycle of their central air conditioning and heat pumps weekdays between June 1 and September 30 (excluding holidays and weekends). When peak-shaving events (the event) are initiated, a radio frequency paging signal (the signal) is broadcast and received by load curtailment switches (the switch) installed on participating customers' central air conditioners and heat pumps. The dispatch of the signal to the switch reduces the duty cycle of the registered AC units while the event is in progress.
- Non-residential Distributed Generation (Virginia): This program provides qualifying non-residential customers with an incentive to curtail load by operating on-demand backup generation for a limited

number of hours per year. Eligible customers are those with at least 200 kW of demand and participant sites are those with an installed generator.

2.1.4 Closed Programs

Each of the following programs was offered in Virginia and North Carolina, with the exception of the Residential Lighting program, which was only offered in Virginia. All programs listed below are no longer offered in either state:

- DSM Phase I, Residential Lighting: During this program's operation, Dominion Energy partnered with manufacturers and retailers to give residential participants an instant discount for high-efficiency compact fluorescent lamp (CFL) lighting purchases.
- DSM Phase I, Commercial Lighting: During its operation, this program provided non-residential customers with an incentive to retrofit their existing inefficient lighting systems with more cost-effective, energy-efficient lighting equipment or to install new high-efficiency lighting equipment.
- DSM Phase I, Commercial HVAC Upgrade: During its operation, this program provided non-residential customers with an incentive to upgrade inefficient HVAC units or to install new high-efficiency HVAC units and motor controls. High-efficiency HVAC installations helped ensure customers that their heating and cooling systems were running at maximum efficiency while minimizing energy consumption.
- DSM Phase I, Residential Low-Income: This program, marketed as the Income Qualifying Home Improvement Program, provided low-income homeowners and renters with a free energy audit that identified and installed energy conservation measures within their residences to help save electricity. This program has been replaced with the Residential Income and Age Qualifying Home Improvement program in both states.

2.2 Report Structure

Section 3 of this report provides an overview of the methodology used in 2017 and the planned research activities for 2018. Sections 4 through 7 discuss the EM&V results of the different programs. In particular, Section 4 reviews the residential EE programs, Section 5 the non-residential EE programs, Section 6 the peak shaving programs, and Section 7 the closed programs. For each active program, DNV GL reports on the following:

- Program description summary
- Initial program-design planning assumptions
- Methods used for the current reporting period
- An assessment of program progress compared to plan, including:
  - cumulative indicators over time compared with planned indicators for program costs, participation, and resource savings (kWh/year and/or kW)
  - average indicators of program costs, participation, and resource savings

This report concludes with 18 appendices:

1. Appendix A: Program Performance Indicator Tables for Virginia Programs 2010–2017
2. Appendix B: Program Performance Indicator Tables for North Carolina Programs 2011–2017

3. Appendix C: Program to Date Gross Energy Savings Tables for Virginia and North Carolina Programs 2010-2017
4. Appendix D: Program to Date Net Energy Savings Tables for Virginia and North Carolina Programs 2010-2017
5. Appendix E: Glossary of Terms
6. Appendix F: Standard Tracking and Engineering Protocols (STEP) Manual Version 8.0.0
7. Appendix G: Residential Income and Age Qualifying Home Improvement Program EM&V Plan
8. Appendix H: Residential Appliance Recycling Program EM&V Plan
9. Appendix I: Residential Retail LED Lighting Program EM&V Plan
10. Appendix J: Non-residential Lighting Systems & Controls Program EM&V Plan
11. Appendix K: Non-residential Heating and Cooling Efficiency EM&V Plan
12. Appendix L: Non-residential Window Film EM&V Plan
13. Appendix M: Non-residential Small Business Improvement Program EM&V Plan
14. Appendix N: Non-residential Prescriptive Program EM&V Plan
15. Appendix O: Residential Air Conditioner Cycling Program EM&V Plan
16. Appendix O-1: Residential AC Cycling Program, Impact Evaluation of 2017 Dispatch Events
17. Appendix P: Non-residential Distributed Generation Program EM&V Plan
18. Appendix P-1: Non-residential Distributed Generation Analysis for 2017 Event Season

3 METHODOLOGIES

3.1 Calculation of the Value of Resources Saved

In the absence of a statewide protocol providing methods for calculating gross and net annual energy savings and peak demand reduction, Dominion Energy has contracted with DNV GL to develop the STEP Manual (Appendix F). The STEP Manual is a Dominion Energy-specific technical reference manual of engineering protocols for estimating gross annual electric energy savings and peak demand reductions.

The protocols are limited to per-unit annual energy savings and peak demand reductions at the measure level, and do not include the calculation for the value of resources saved. To calculate the value of the resource savings for reporting and other purposes, the energy savings are determined at the measure level, aggregated at the program level, and reported through this annual report. The savings are then increased by the amount of the transmission and distribution (T&D) losses to reflect the energy savings at the system level. Energy savings at the system level are then multiplied by the appropriate avoided costs to calculate the value of the benefits.

$$System\ savings = Savings\ at\ measure \times T\&D\ loss\ factor$$

$$Value\ of\ resources\ saved = System\ savings \times System\ avoided\ costs$$

The durations of expected savings of installed measures are specified in terms of average expected measure life in years by program, and are discussed in more detail in Section 3.1.2, Measure Life, below.

3.1.1 Transmission and Distribution System Losses

These protocols calculate gross annual energy savings at the measure level, which should be increased by transmission and distribution (T&D) system losses in order to determine gross annual energy savings at the system level. The T&D loss factor multiplied by the savings calculated from the protocols will result in savings at the supply level.

The T&D electric loss factor is approximately 1.05 as a system-wide average (for both energy and demand), to be applied to savings at the customer meter. Dominion Energy provided this factor to DNV GL, which was developed internally for Dominion Energy's programs as part of its IRP process.

3.1.2 Measure Life

Measure lives are provided in Table 3-1 and at the end of each section of the STEP Manual (Appendix F) for estimating lifetime savings for planning or in benefit-cost studies spanning more than one year. Measure lives were included in the initial planning assumptions as filed with the SCC and NCUC when each program was considered for approval. Programs' measure lives are a composite estimate of the associated measures that comprise the program.

Table 3-1. Measure life assumptions

Program	Measure Life (Years)
Residential Programs	
Residential Appliance Recycling	8.0
Residential Duct Testing and Sealing	18.0
Residential Heat Pump Tune-Up	5.0

Program	Measure Life (Years)
Residential Heat Pump Upgrade	15.0
Residential Home Energy Check-up	10.0
Residential Income and Age Qualifying Home Improvement	14.0
Residential Lighting	9.4
Residential Low Income	13.6
Residential Retail LED Lighting	20.0
Non-residential Programs	
Non-residential Duct Testing and Sealing	25.0
Non-residential Energy Audit	7.0
Non-residential Heating and Cooling	15.0
Non-residential Lighting & Controls	9.0
Non-residential Prescriptive	6.3
Non-residential Small Business Improvement	14.0
Non-residential Window Film	10.0
Commercial HVAC Upgrade	15
Commercial Lighting	10
Peak Shaving Programs	
Residential AC Cycling	15.0
Non-residential Distributed Generation	N/A

3.1.3 Net Savings Estimation

The STEP Manual protocols are designed to estimate gross savings program impacts, or more specifically, the total amount of annual energy savings and peak demand reductions related to program activity. However, the amount of energy savings and demand reductions that can be attributed to the program is not the same as the estimated gross savings. This is because any given program's design can have intended and unintended outcomes. The amount of energy savings and demand reductions that can be attributed to the program is referred to as net savings, which is the magnitude of the impact of the program's intended outcomes.

The most common unintended outcomes of an energy efficiency (EE) or peak shaving program can be characterized as follows:

- **Free-ridership:** program participants who consume the incentive, but were not influenced by the program through which the measure is delivered, thereby reducing gross savings.
- **Participant "Like" Spillover:** past program participants who subsequently install those same program-eligible EE measures, but do not consume the incentive, having been already influenced by the program through which the measure is delivered, thereby increasing gross savings.
- **Participant "Unlike" Spillover:** past program participants who subsequently install other EE measures not offered through the program, but who have been influenced by the original program, thereby increasing gross savings.
- **Non-participant Spillover:** program non-participants who were influenced by the program through which the measure is delivered and implement the measure without consuming the program.

incentive, potentially increasing gross savings. The influence may happen upstream at the design or specification stage without the customer's input or knowledge. This is also commonly referred to as "free drivers."

- **Leakage:** program non-participants who receive the measure and consume the incentive but install the measure outside of Dominion Energy's service territory, thereby reducing gross savings.
- **Snapback:** program participants who receive the measure and consume the incentive, but alter behavior in such a way that the participants' or non-participants' energy and demand are higher than the baseline for the given measure.

Table 3-2 summarizes which unintended outcomes are included in DNV GL's impact evaluations.

Table 3-2. Status of Unintended Outcome Included in DNV GL Impact Evaluations

Unintended Outcome Category	Status of Impact Evaluations
Free-ridership	Included in all previous impact evaluations
Participant "Like" Spillover	Included only in the previous Non-residential Energy Audit program impact evaluation
Participant "Unlike" Spillover	Not included at this time
Non-participant Spillover	Not included at this time
Leakage	Not included at this time
Snapback	Not included at this time

The combination of all adjustments made to the items listed in Table 3-3 is typically referred to as the net-to-gross (NTG) factor and is summarized by program. In this report, default NTG ratios are the *ex ante* values specified by Dominion Energy. These values will be updated over time as NTG is measured for each program. NTG factors typically change as programs mature and extend beyond the early adopters to the mass market.

NTG factors may be estimated a number of ways. The energy efficiency evaluation industry discussion of various approaches are described in Chapter 21, Estimating Net Savings – Common Practices, [15] produced under the Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures,[16] for the U.S. Department of Energy and the general public. This document also references the Energy Efficiency Program Impact Evaluation Guide, which provides additional details.[17]

[15] Chapter 21: Estimating Net Savings – Common Practices. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. October 2017. https://www.nrel.gov/docs/fy17osti/68578.pdf. Accessed April 9, 2018.

[16] Uniform Methods Project for Determining Energy Efficiency Program Savings. U.S. Department of Energy. https://www.energy.gov/eere/about-us/ump-home. Accessed April 9, 2018.

[17] Energy Efficiency Program Impact Evaluation Guide. Evaluation, Measurement, and Verification Working Group. State & Local Energy Efficiency Action Network. December 2012. https://www4.eere.energy.gov/seeaction/system/files/documents/emv_ee_program_impact_guide_0.pdf. Accessed April 9, 2018.

Table 3-3. Net-to-Gross Factors and Sources by Program

Program	Net-to-Gross Factor	Source
Residential Programs		
Residential Appliance Recycling	77%	Dominion Energy program design assumption
Residential Duct Sealing	80%	Dominion Energy program design assumption
Residential Heat Pump Tune-Up	90%	Dominion Energy program design assumption
Residential Heat Pump Upgrade	45%	DNV GL, April 2015 for Dominion Virginia Power
Residential Home Energy Check-up	82%	DNV GL, April 2015 for Dominion Virginia Power
Residential Income and Age Qualifying Home Improvement	80%	DNV GL, April 2015 for Dominion Virginia Power
Residential Lighting	65%	Dominion Energy program design assumption
Residential Low Income	94%	KEMA, April 2011 for Dominion Virginia Power
Residential Retail LED Lighting	85%	Dominion Energy program design assumption
Non-residential Programs		
Non-residential Duct Testing and Sealing	97%	DNV GL, April 2015 for Dominion Virginia Power
Non-residential Energy Audit	98%	DNV GL, April 2015 for Dominion Virginia Power
Non-residential Heating and Cooling	70%	Dominion Energy program design assumption
Non-residential Lighting Systems & Controls	70%	Dominion Energy program design assumption
Non-residential Prescriptive	85%	Dominion Energy program design assumption
Non-residential Small Business Improvement	93%	Program design assumption
Non-residential Window Film	80%	Program design assumption
Commercial Lighting	50%	KEMA, October 2011 Commercial Lighting Program: Load Shape and Net Savings Analysis Evaluation Report
Commercial HVAC	45%	KEMA, April 2012 Commercial HVAC Program: Load Shape and Net Savings Analysis Evaluation Report
Peak Shaving Programs		
Residential AC Cycling	100%	KEMA, October 2011 Operability Study replaced net-to-gross. Required by PJM and not applicable in 2017
Non-residential DG	100%	

3.2 Data Quality and Validation

3.2.1 Methodologies

In cooperation with Dominion Energy, DNV GL has developed data quality and validation procedures to help ensure program data are consistent and accurate. Importantly, participant counts, gross annualized energy savings, and peak demand reduction result from engineering equations that use these validated data from the Company as inputs.

Program data used to calculate gross annualized energy savings must meet predefined data requirements as agreed upon by DNV GL, the Company, and the program implementation vendor. The data requirements are developed after a program is approved by the Commission and before the program is launched. The program implementation vendor is responsible for program data collection and data entry. This data is then transferred to the Company's Business Intelligence (BI) database for quality control and verification. The Company then transfers EM&V-specific data to DNV GL. The data requirements define:

- Variable name
- Variable description
- Data type (e.g., numeric, character, and date)
- Maximum field length
- Validation range (where appropriate)
- Necessity of variable to compute savings

The validation range comes in the form of a structured list of acceptable text variables or a range for numeric variables. If the data contain a text variable that does not match the values defined in the structured list, then that record will not be processed. If the data contain a numeric variable that does not fall within the validation range, then that data is removed by the Company. The validation ranges were carefully constructed to exclude unrealistic records while not excluding unusual records.

Each month the data is reviewed for the following:

1. **Are the correct data being collected for EM&V purposes?** This would include the data containing the requisite database fields for calculations using the STEP Manual (Appendix F) and for future sampling needs for data analysis, modeling, and survey research.
2. **Are the data well populated?** Large databases are rarely completely populated, but some data are critical and cannot be overlooked.
3. **Are the data generally consistent with expectations according to range and consistency checks?** Any exceptionally large or small values are noted and verified where appropriate.

At least annually, DNV GL conducts two types of quality checks on the code and the results to confirm that they are consistent with engineering expectations and the STEP Manual protocols. These activities check for outliers in the data at a macro level and individual record level results for consistency with the intentions of the protocols.

Additionally, DNV GL and the Company work closely together to review DSM program participant data on a monthly basis. DNV GL also has all of the Company's historic DSM program data and results since program inception, which are further utilized to check and audit historic calculations annually when the STEP Manual is updated and make corrections as necessary in the year-end reporting.

All of these activities are intended to ensure the highest level of data integrity.

3.2.2 Adjustments and/or Corrections to Prior Year Calculations

DNV GL made adjustments and corrected savings calculations that affected the reported savings for program year 2016 for a number of programs that were reported in the May 1, 2017, EM&V reporting of Dominion Energy's DSM Programs. Some of those corrections were substantial, and warranted correcting the 2016 program data retroactively. Those corrections were resubmitted to Commissions in Virginia in January 2018 and in North Carolina in December 2017. Others were not substantial. They were not retroactively corrected in the 2016 program data, but were calculated and the difference from what was reported in the May 1, 2017 report was added to the January 2017 results shown in this report to fully account for them. The following tables summarizes those changes:

- Table 3-4 describes the adjustments that were made, the location in the May 1, 2017 EM&V report, and a brief explanation of the reason for the correction.
- Table 3-5 describes the impacts of the adjustments made to values reported in the May 1, 2017 version of the EM&V report.

Table 3-4. Explanation of Adjustments

Appendix Section and Title in May 1, 2017 EM&V Report	Location of Correction	Reason for Correction
1. Adjustments to non-residential lighting retrofit measure assumptions about building HVAC type in 2016 deemed savings equation. This affected the waste heat factor (energy and demand) for these measures.		
Appendix E. Section 9.1.1. Lighting Fixtures, Lamps and Delamping	Table 89. Non-residential Lighting Parameters by Facility Type	Adjusted waste heat factors (WHF_e and WHF_d) applied to lighting fixtures installed in 2016. Assumed program participant build HVAC systems to be heat pump heating and cooling systems, rather than previously assumed AC cool and non-electric heat systems, in response to requests by the North Carolina Public Staff Utilities Commission Re: Docket No. E-22, Sub 545, on October 23, 2017.
Appendix E. Section 11.1.3. LED Reflector Lamp & A-line LED Note: While this adjustment applies to the Non-residential Energy Audit program, there were no lighting measures installed in 2016 in either states. Therefore, no adjustments were necessary for this program		
Appendix E. Section 15. Non-residential Small Business Improvement Program, Lighting, Fixtures, Lamps, and Delamping measure		
2. Adjustments to non-residential HVAC measure full load heating hours in 2016 deemed savings equation.		
Appendix E. Section 10.1.1. Unitary / Split HVAC and Heat Pumps	Table 33. Input Values for Non-residential HVAC Equipment, FLH_{heat} and FLH_{cool} Table 90. Full Load Cooling Hours for Non-residential Buildings Table 91. Heat Pump, VRF, and Mini Split Full Load Heating Hours for Non-residential Buildings	Adjusted full load heating hours (FLH_{heat}) in Table 90 and Table 91 to be consistent with those in the Mid-Atlantic TRM v.6. This is in response to requests by the North Carolina Public Staff Utilities Commission Re: Docket No. E-22, Sub 545, on October 23, 2017. This affects multiple non-residential HVAC measures (e.g. heat pumps, variable refrigerant flow, mini split systems) that reference Table 90 and 91, in multiple non-residential programs.
Appendix E. Section 10.1.2. Variable Refrigerant Flow Systems and Mini Split Systems	Table 37. Input Values for VRF Systems and Mini Split Systems, FLH_{heat} and FLH_{cool} Table 90. Full Load Cooling Hours for Non-residential Buildings Table 91. Heat Pump, VRF, and Mini Split Full Load Heating Hours for Non-residential Buildings	

Appendix Section and Title in May 1, 2017 EM&V Report	Location of Correction	Reason for Correction
Appendix E. Section 12. Non-residential Duct Testing and Sealing Program	Table 69. Input Values for Duct Sealing Savings Calculations, FLH_{heat} and FLH_{cool} Table 90. Full Load Cooling Hours for Non-residential Buildings Table 91. Heat Pump, VRF, and Mini Split Full Load Heating Hours for Non-residential Buildings	
Appendix E. Section 15.1.1 Unitary / Split Air Conditioning, Heat Pump, and Chiller Tune-Up	Table 80. Input Variables for AC/HP/Chiller Tune-Up Measure, FLH_{heat} and FLH_{cool} Table 90. Full Load Cooling Hours for Non-residential Buildings Table 91. Heat Pump, VRF, and Mini Split Full Load Heating Hours for Non-residential Buildings	
Appendix E. Section 12. Non-residential Duct Testing and Sealing Program	Table 90. Full Load Cooling Hours for Non-residential Buildings	Error correction in the calculation for North Carolina. The full load cooling hours for North Carolina in the code did not match the values in the STEP Manual.
3. Correction to Residential Home Energy Check-Up and Residential Income and Age Qualifying Home Improvement low-flow showerhead measure ΔT value, in 2016 deemed savings equation.		
Appendix E. Section 2.1.5 Low-Flow Showerhead	Table 8: Input Values for Low-Flow Shower Head Savings Calculations	Corrected "Low-Flow Showerhead" measures, "ΔT" variable calculated value from 44.9°F (reported in STEP Manual 7.0.0) to 44.1°F (in Appendix F, STEP Manual 8.0.0, of this report.
Appendix E. Section 6.1.2 Low-Flow Showerhead		

Table 3-5. Impact of adjustments

Program and State	Appendix Number in May 1, 2017, report and this report	Category	May 1, 2017, Reported 2016 Year-End Gross Value	Adjusted 2016 Gross Year-End Value (Should match 2016 Gross Year-End Value)	Difference	Difference in %, from May 1, 2017, Reported Value
Residential Home Energy Check-Up Virginia	2017 Report Appendix: A.4 and B.4 This Report Section: 4.4	Total Gross Deemed Savings (kWh/year	6,803,477 kWh/year	N/A. Difference included in January 2017 value	24,556.1 kWh/year	0.4%
		Total Gross Demand Reduction (kW)	693 kW		1.64 kW	0.2%
Residential Home Energy Check-Up North Carolina		Total Gross Deemed Savings (kWh/year	1,495 kWh/year		-2.1 kWh/year	-0.1%
		Total Gross Demand Reduction (kW)	0.17 kWh		-0.00044 kW	-0.3%
Residential Income and Age Qualifying Home Improvement Program Virginia	2017 Report Appendix: A.5. and B.5 This Report Section: 4.5	Total Gross Deemed Savings (kWh/year	3,575,492 kWh/year		-12,182.94 kWh/year	-0.3%
		Total Gross Demand Reduction (kW)	398 kW		-1.10 kW	-0.3%
Residential Income and Age Qualifying Home Improvement Program North Carolina		Total Gross Deemed Savings (kWh/year	106,379 kWh/year		-306.89 kWh/year	-0.3%
		Total Gross Demand Reduction (kW)	11 kW		-0.03 kW	-0.3%
Non-residential Duct Testing and Sealing Virginia	2017 Report Appendix: A.7. This Report Section: 5.1	Total Gross Deemed Savings (kWh/year)	57,202,610 kWh/year	26,352,640 kWh/year	-30,849,970 kWh/year	54%
		Total Gross Demand Reduction (kW)	2,594 kW	2,594 kW	0 kW	0%
Non-residential Duct Testing and Sealing North Carolina	2017 Report Appendix: B.6. This Report Section: 5.1	Total Gross Deemed Savings (kWh/year)	633,600 kWh/year	550,135 kWh/year	-83,464 kWh/year	13%
		Total Gross Demand Reduction (kW)	160 kW	160 kW	0 kW	0%

Program and State	Appendix Number in May 1, 2017, report and this report	Category	May 1, 2017, Reported 2016 Year-End Gross Value	Adjusted 2016 Gross Year-End Value (Should match 2016 Gross Year-End Value)	Difference	Difference in %, from May 1, 2017, Reported Value
Non-residential Lighting Systems and Controls	2017 Report Appendix: A.9.	Total Gross Deemed Savings (kWh/year)	80,739,463 kWh/year	65,876,985 kWh/year	-14,862,478 kWh/year	-18%
Virginia	This Report Section: 5.3	Total Gross Demand Reduction (kW)	15,212 kW	15,380 kW	168 kW	1%
Non-residential Lighting Systems and Controls	2017 Report Appendix: B.8.	Total Gross Deemed Savings (kWh/year)	3,814,664 kW/year	3,333,527 kWh/year	-481,137 kWh/year	-13%
North Carolina	This Report Section: 5.3	Total Gross Demand Reduction (kW)	718 kW	743 kW	26 kW	4%
Non-residential Heating and Cooling Efficiency	2017 Report Appendix: A.10.	Total Gross Deemed Savings (kWh/year)	13,801,883 kWh/year	13,647,306 kWh/year	-154,576 kWh/year	-1%
Virginia	This Report Section: 5.4	Total Gross Demand Reduction (kW)	2,084 kW	2,084 kW	0 kW	0%
Non-residential Heating and Cooling Efficiency	2017 Report Appendix B.9.	Total Gross Deemed Savings (kWh/year)	312,404 kWh/year	289,500 kWh/year	-22,904 kWh/year	-7%
North Carolina	This Report Section: 5.4	Total Gross Demand Reduction (kW)	93 kW	93 kW	0 kW	0%
Non-residential Small Business Improvement	2017 Report Appendix: Appendix A.12.	Total Gross Deemed Savings (kWh/year)	828,569 kWh/year	656,801 kWh/year	-171,768 kWh/year	-21%
Virginia	This Report Section: 5.6	Total Gross Demand Reduction (kW)	129 kWh/year	132 kW		2%

3.3 Research Activities through 2017

The EM&V approach incorporates deemed annualized energy savings and demand reduction calculations outlined in the STEP Manual (Appendix F), customer surveys, billing analyses using customer data, and on-site evaluations at customer homes and businesses. Each year, as scheduled in the EM&V plans, DNV GL undertakes various research activities across the Company's DSM programs to evaluate each program through impact evaluations. The following research activities are used to evaluate the DSM programs:

- **Data Quality Review:** DNV GL reviews the program tracking data to ensure they have all the necessary information to compute savings and to feed into potential future evaluation research data requirements. DNV GL performs data quality review on a monthly basis throughout the year for all programs and performs an in-depth data quality check at least twice a year for all programs. Section 3.2 provides more details about the data quality reviews that DNV GL conducts.
- **Deemed Savings Calculations:** DNV GL estimates energy savings and peak demand reductions across programs with standardized calculations and assumptions outlined in the STEP Manual. DNV GL tracks deemed estimates for all programs on a monthly basis throughout the year and reports draft deemed estimates to Dominion Energy each month.
- **Satisfaction Surveys:** Satisfaction survey questions help the Company determine how satisfied its customers are with the programs it offers. These questions generally cover satisfaction with the program as a whole, the rebate application and payments, and, if applicable, the contractors used. This survey is often combined with a NTG estimation or verification survey (sometimes both) to reduce the number of interactions with the participant.
- **Billing Analysis:** This approach applies Company-specific customer usage data to actual participating households or facilities to quantify annualized energy savings and peak demand reductions for a program. DNV GL analyzes monthly billing data from households or facilities for a 12-month period before and after the audit/install date of a program measure. The savings calculated from this method allow DNV GL to create an adjustment factor to the engineering algorithms known as a realization rate. This realization rate is then applied to future deemed calculations for savings.
- **NTG Estimation Surveys:** Depending on the program design and the evaluation methodology used, survey research methods can be used to estimate the NTG factor, which is the percentage of savings that are attributable to the program because participants would not have performed the program measures in the absence of the program. This survey is often combined with the satisfaction and verification surveys, and conducted during a single interaction with the participant and/or contractor.
- **Verification Surveys:** Survey verification questions help verify the customer did participate in the program and install any or all measures as recorded in the tracking data. The survey results are used to calculate a verification rate that is applied to the deemed savings. This survey is often combined with the satisfaction survey and NTG-estimation survey and conducted during a single interaction with the participant.
- **On-site Verification:** This occurs when a member of the evaluation team visits a random selection of sites and verifies that the measures are actually installed. This may be used in conjunction with or in place of verification surveys to help the Company verify program participation and measure installation.

- **On-site Measurement:** This is physical verification of an installed measure's power load and energy usage through the use of metering equipment. The measurement results help make deemed savings calculations more accurate and precise.
- **Building Simulation Modeling:** When on-site measurement is not available at the measure-level, or where interactive effects of multiple installed measures cannot be determined, modeling is used to more accurately determine measured power load and energy usage of multiple measures installed at a single site. Like on-site measurement, the results of modeling help the Company to adjust its deemed savings calculations.
- **Load-Shape Analysis:** The Company conducts a load-shape analysis using data from a combination of data inputs (e.g., on-site verification, on-site measurement, and modeling) to determine each program's annual power load profile for the Company-specific system peak and for PJM-defined performance periods.[18]

Table 3-6 on the next page provides an overview of the research activities conducted for each program through the end of 2017. The years listed in the table represent the year that the EM&V study report was published. All programs undergo data quality review and evaluation using deemed calculations.

[18] PJM is the Company's regional transmission organization (www.pjm.com).

Table 3-6. EM&V Research Activities Conducted Through 2017 by Program

Program	Data Quality Review	Deemed Savings Calculations	Billing Analysis	Satisfaction Survey	Verification Survey	NTG Studies	On-Site Verification	On-Site Measurement	Building Simulation Modeling	Load-Shape Analysis	Other
Residential Programs											
Residential Appliance Recycling	2016-present	2016-present								2016-present	
Residential Duct Sealing	2012-present	2012-present		2015	2015					2015-present	
Residential Heat Pump Tune-Up	2012-present	2012-present		2015	2015					2015-present	
Residential Heat Pump Upgrade	2012-present	2012-present		2015, 2016	2015, 2016	2015, 2016	2015, 2016	2015, 2016		2015-present	
Residential Home Energy Check-up	2012-present	2012-present	2015-2016	2015, 2016	2015, 2016	2016				2015-present	
Residential Income and Age Qualifying Home Improvement	2016-present	2016-present								2016-present	
Residential Retail LED Lighting	2017	2017								2017	
Non-residential Programs											
Non-residential Duct Testing and Sealing	2012-present	2012-present		2015	2015	2015	2015			2015-present	
Non-residential Energy Audit	2012-present	2012-present		2015	2015	2015	2015	2015		2015-present	
Non-residential Heating & Cooling	2015-present	2015-present								2015-present	
Non-residential Lighting Systems & Controls	2015-present	2015-present								2015-present	
Non-residential Prescriptive	2017	2017								2017	
Non-residential Small Business Improvement	2016 - present	2016 - present								2016 - present	
Non-residential Window Film	2015-present	2015-present								2015-present	
Peak Shaving Programs											
Residential AC Cycling	2010-present	2010-present	2012-2017				10/2011			2015-present	
Non-residential Distributed Generation	2013-present	2013-present	2013-2017							2015-present	
Closed Programs											
Commercial HVAC (Closed)	2010-2013, 2015	2010-2013, 2015				4/2012	4/2012	4/2012			

Program	Data Quality Review	Deemed Savings Calcu-lations	Billing Analysis	Satis-faction Survey	Verifi-cation Survey	NTG Studies	On-Site Verifi-cation	On-Site Meas-ureme nt	Building Simula-tion Modeling	Load-Shape Analysis	Other
Commercial Lighting (Closed)	2010-2013, 2015	2010-2013, 2015				4/2012	4/2012	4/2012			
Residential Lighting (Closed)	2010-2012	2010-2012									Retail sales survey (4/2011)
Residential Low Income (Closed)	2010-2016	2010-2016	4/2012-2014	4/2011		4/2011					

3.4 Planned Research Activities in 2018

In 2018, DNV GL will begin a new cycle of EM&V activities for all of Dominion Energy's active programs. Those activities will be the same as the activities conducted for 2017, as shown above in Table 3-6. An in-depth description of the planned activities for each program is provided in Appendices G through O of this report.

In October 2017, in Case No. PUR-2017-00129, the Company filed for an extension of the DSM Phase IV Residential Income and Age Qualifying Home Improvement Program. Similar to the DSM Phase II programs, should any residual tracking data from the end of 2017 remain to be processed by DNV GL in 2018, there may be minimal EM&V activities for this program in 2018.

The SCC issued its order regarding new rules governing the EM&V of the effects of utility-sponsored DSM programs (Case No. PUR-2017-00047) on November 9, 2017. The new rules apply prospectively to new or renewing DSM programs starting from the order date. As of this EM&V report, there have been no new or renewing DSM programs. Should the above mentioned DSM Phase IV Residential Income and Age Qualifying Home Improvement Program be renewed by the SCC, it will be the first program to adhere to these new rules in 2018.

4 ENERGY EFFICIENCY PROGRAMS – RESIDENTIAL

This section reports on residential EE program progress in 2017 for a total of seven residential EE programs. Of those, five programs were available in both Virginia and North Carolina, one was available in Virginia only, and another was available in North Carolina only. The programs available in both states are as follows:

1. Residential Heat Pump Upgrade (DSM Phase II)
2. Residential Heat Pump Tune-up (DSM Phase II)
3. Residential Duct Sealing (DSM Phase II)
4. Residential Home Energy Check-up (DSM Phase II)
5. Residential Income and Age Qualifying Home Improvement (DSM Phase IV)

The Residential Appliance Recycling program (DSM Phase IV) was only available in Virginia and has closed, as intended, in 2017. The Residential LED Lighting program (DSM Phase V) was only available in North Carolina in 2017 and will continue to be only available in North Carolina in 2018.

This is the last EM&V report that will show new participants for the DSM Phase II programs listed above, because those programs have closed as intended. Those programs operated in Virginia for five years, and for three years in North Carolina. The DSM Phase II program data in this report are from services that were completed by participating contractors by December 24, 2016, with rebate applications received by Dominion Energy by February 7, 2017.

Cumulatively, from program inception through the end of 2017, there have been 188,766 participants across all six residential programs (excluding the Residential Retail LED Lighting program, because participation in that program is measured in lamps rather than households). Residential programs account for 94% of all residential and non-residential DSM program participants. The cumulative net annualized energy savings from these programs (including the Residential Retail LED Lighting program) were 83,315,420 kWh/year, or 22% of all DSM program energy savings.

Figure 4-1 and Figure 4-2 show the cumulative count of residential EE program participation and gross annualized energy savings in the two states, at the county level with the exception of the Residential Retail LED Lighting program.[19] The more intense the color, the greater the participation and gross annualized energy savings.

The top three jurisdictions in Virginia with the highest participation are Chesterfield, Henrico, and Virginia Beach City, in decreasing order. In North Carolina, the top three jurisdictions (in decreasing order) with the highest participation are Dare, Currituck, and Halifax.

In terms of energy savings, the top three jurisdictions in Virginia with the highest gross annualized energy savings (in decreasing order) are Chesterfield, Fairfax, and Henrico. And in North Carolina the top three jurisdictions (in decreasing order) with the highest energy savings are Dare, Currituck, and Pasquotank.

[19] Program data not available in the format required to be included in maps.

Figure 4-1. VA and NC Residential Energy Efficiency Program Participation Map, by County, Inception to December 31, 2017

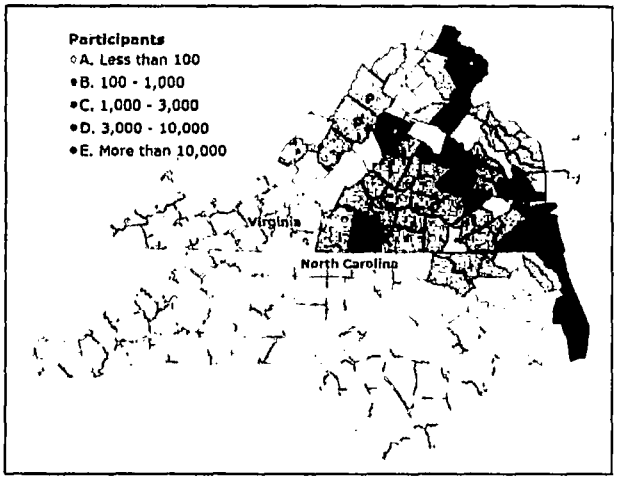
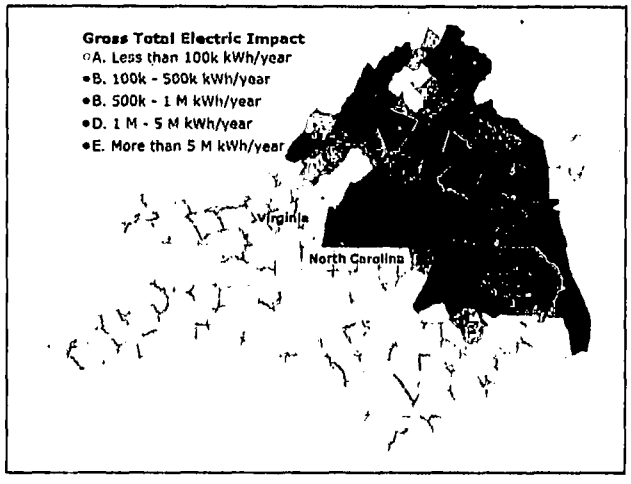


Figure 4-2. VA and NC Residential Energy Efficiency Program Gross Annualized Energy Savings Map, by County, Inception to December 31, 2017



4.1 Residential Heat Pump Upgrade – Virginia and North Carolina

The now-closed DSM Phase II Residential Heat Pump Upgrade Program provided incentives to Virginia and North Carolina residential customers who installed a new, greater efficiency (ENERGY STAR®-rated) air or geothermal heat pump unit. To be eligible for the program, customers were required to live in single-family residences, townhomes, or multi-family housing (apartments and condos) with electric heating and cooling with an air source heat pump, and either own the home or be able to obtain permission from the owner to perform the repairs or improvements. Qualifying equipment was required to have better seasonal EE ratio (SEER) and heating seasonal-performance factor (HSPF) ratings than the nationally mandated efficiency standards. Existing homes qualified for the program if the heat pump SEER rating was 14.5 or greater and the HSPF rating was 8.2 or greater. New homes qualified if the heat pump SEER rating was 15 or greater and the HSPF rating was 8.2 or greater. Customers were eligible for one upgrade per unit during the six-year program time period.

This program was implemented through a contractor network, so customers were required to contact a participating contractor to be eligible for the rebate. Customers were not considered participants until a completed application form was processed and a rebate issued. This process could take several months since the customers had 45 days to submit their rebate application, and the Company had 90 days to process it.

In 2016, Dominion Energy announced the program closed to new participants in both states, and that to be eligible for a rebate, the service must have been completed by a participating contractor by December 24, 2016, and rebate applications received by February 7, 2017. The rebate form submission and processing

time all together can add up to 135 days before a participant shows up in the tracking and reporting system. This report section shows those final enrollments of 2017 that were serviced in the last months of 2016.

Dominion Energy filed an application with the SCC to continue this program, but it was not approved,[20] as previously mentioned in Section 1.

4.1.1 Methods for the Current Reporting Period

For the current period, the approach included reviewing the tracking data and then estimating gross energy savings and peak demand reduction using STEP Manual calculations with the realization rate estimated from the 2015-2016 load shape study.

Table 4-1 outlines Dominion Energy's initial program planning assumptions that were used to design the program.

Table 4-1. Residential Heat Pump Upgrade Program Planning Assumptions System-wide

Item	Description
Target Market	Residential customers with eligible HVAC systems
NTG Factor	85%
Measure Life	15 years
Average Energy Savings (kWh) per Participant per Year	856 kWh per participant per year
Average Peak Demand Reductions (kW) per Participant	0.29 kW per participant per year
Average Rebate (US $) per Participant	$205 per participant

4.1.2 Assessment of Program Progress Towards Plan

The next section describes the program's progress towards planned participants, energy savings, and peak demand reductions.

4.1.2.1 Key Virginia and North Carolina Program Data

Table 4-2, Figure 4-3, and Figure 4-4 on the next pages summarize key indicators of progress in Virginia from August 2012 through December 2017. Table 4-3, Figure 4-5, and Figure 4-6, also on the following pages, summarize key indicators of progress in North Carolina from January 2014 through December 2017.

Detailed monthly program indicators for Virginia appear in Appendix A.1 and for North Carolina in Appendix B.1.

[20] Case PUE-2016-00111. June 1, 2017.

Table 4-2. VA Residential Heat Pump Upgrade Program Performance Indicators (2012-2017)

Category	Item	Virginia 2012	2013	2014	2015	2016	2017	Program Total (2012-2017)
Operations and Management Costs ($)	Direct Rebate							
	Direct Implementation							
	Direct EM&V							
	Indirect Other (Administrative)	$126,049	$202,451	$101,388	$76,038	$78,750	$29,454	$614,131
Total Costs ($)	Total							
	Planned							
	Variance							
	Cumulative % of Planned	52%	50%	36%	43%	41%	142%	45%
Participants	Total (Gross)	86	3,295	3,649	4,210	5,395	1,149	17,784
	Planned (Gross)	4,396	11,992	18,221	18,221	3,748	0	56,578
	Variance	-4,310	-8,697	-14,572	-14,011	1,647	1,149	-38,794
	Cumulative % of planned (Gross)	2%	27%	20%	23%	144%	N/A	31%
Installed Energy Savings (kWh/year)	Total Gross Deemed Savings	199,447	6,665,695	5,667,002	2,405,953	3,072,240	553,935	18,564,272
	Realization Rate Adjustment (78%)[21]	13,363	446,602	379,689	-538,933	-688,182	-124,081	-511,543
	Adjusted Gross Savings	212,810	7,112,296	6,046,691	1,867,020	2,384,058	429,854	18,052,729
	Net-to-Gross Adjustment (45%)[22]	-31,922	-1,066,844	-907,004	-1,024,994	-1,308,848	-235,990	-4,575,601
	Net Adjusted Savings	180,889	6,045,452	5,139,687	842,026	1,075,210	193,864	13,477,128
	Planned Savings (Net)	3,207,000	8,724,528	15,761,165	15,761,165	742,316	0	44,196,174

[21] Realization rate adjustment for 2012-2014 was 107%. Starting in 2015, the realization rate adjustment was updated to 77.6% based on the 2015 Load Shape Study.

[22] NTG adjustment for 2012-2014 was 85% per the program planning assumptions. Starting in 2015, the NTG adjustment was updated to 45.1% based on the 2015 Net-to-Gross Characterization Study.

Category	Item	Virginia						
		2012	2013	2014	2015	2016	2017	Program Total (2012-2017)
	Cum. % Toward Planned Savings (Net)	6%	69%	33%	5%	145%	N/A	30%
	Avg. Savings per Participant (Gross)	2,319	2,023	1,553	571	569	482	1,044
	Avg. Savings per Participant (Net)	2,103	1,835	1,409	200	199	169	758
Installed Demand Reduction	Total Gross Deemed Demand	59	2,394	2,169	472	624	130	5,848
	Realization Rate Adjustment (89%)[23]	-10	-405	-367	-53	-70	-15	-918
	Adjusted Gross Demand	49	1,989	1,802	419	554	115	4,930
	Net-to-Gross Adjustment (45%)[24]	-7	-298	-270	-230	-304	-63	-1,174
	Net Adjusted Demand	42	1,691	1,532	189	250	52	3,756
	Planned Demand (Net)	1,068	2,904	5,284	5,284	267	0	14,807
	Cum. % Toward Planned Demand (Net)	4%	58%	29%	4%	94%	N/A	25%
	Avg. Demand per Participant (Gross)	0.69	0.73	0.59	0.11	0.12	0.11	0.33
	Avg. Demand per Participant (Net)	0.49	0.51	0.42	0.04	0.05	0.05	0.21
Program Performance	Cum. $Admin. per Cum. Participant (Gross)	$1,466	$61	$28	$18	$15	$26	$35
	Cum. $Admin. per Cum. kWh/year (Gross)	$0.63	$0.03	$0.02	$0.03	$0.03	$0.05	$0.03
	Cum. $Admin. per Cum. kW (Gross)	$2,125	$85	$47	$161	$126	$227	$105
	Cum. $EM&V per Cum. Total Costs ($)	2%	15%	13%	18%	11%	19%	13%

[23] Realization rate adjustment for 2012-2014 was 83%. Starting in 2015, the realization rate adjustment was updated to 88.8% based on the 2015 Load Shape Study.

[24] NTG adjustment for 2012-2014 was 85% per the program planning assumptions. Starting in 2015, the NTG adjustment was updated to 45.1% based on the 2015 Net-to-Gross Characterization Study.

Virginia								
Category	Item	2012	2013	2014	2015	2016	2017	Program Total (2012-2017)
	Cum. $Rebate per Cum. Participant (Gross)							

Figure 4-3. VA Residential Heat Pump Upgrade Cumulative Participation Compared to Planned and Over Time

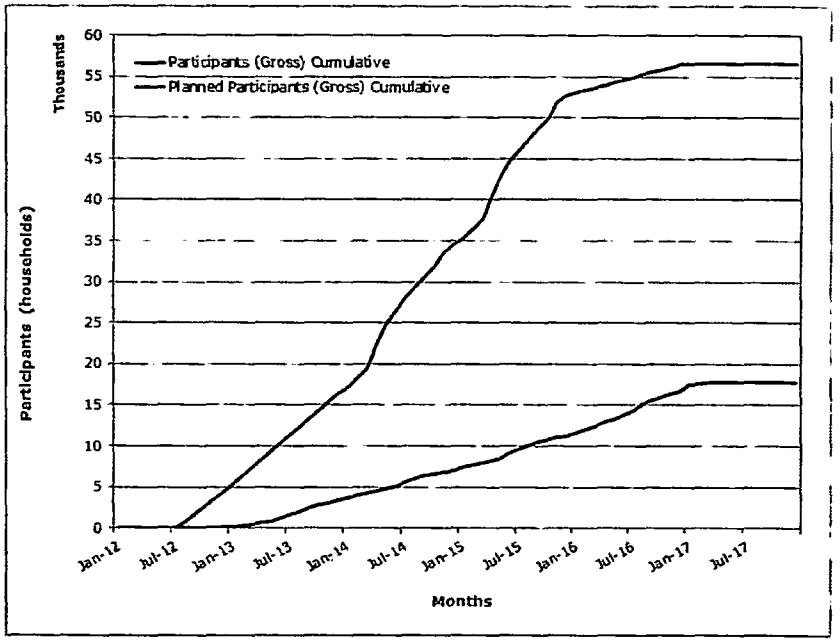


Figure 4-4. VA Residential Heat Pump Upgrade Cumulative Net Adjusted Annualized Savings (kWh/year) Compared to Planned and Over Time

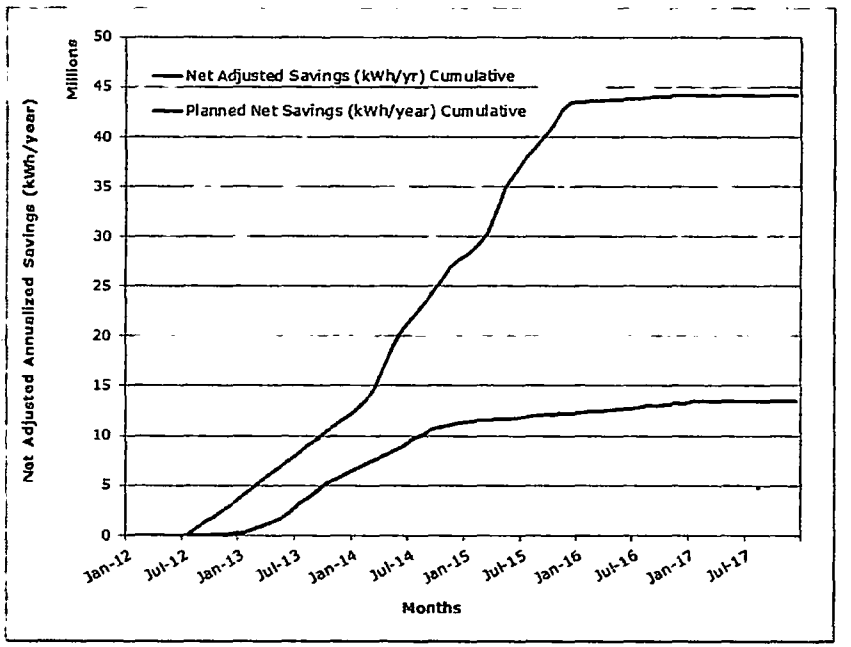


Table 4-3. NC Residential Heat Pump Upgrade Program Performance Indicators (2014-2017)

Category	Item	North Carolina				
		2014	2015	2016	2017	Program Total (2014-2017)
Operations and Management Costs ($)	Direct Rebate	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Direct Implementation	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Direct EM&V	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Indirect Other (Administrative)	$1,847	$7,845	$8,235	$2,527	$20,454
Total Costs ($)	Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Planned	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Variance	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Cumulative % of Planned	14%	70%	64%	191%	55%
Participants	Total (Gross)	44	597	665	118	1,424
	Planned (Gross)	1,200	1,200	252	0	2,652
	Variance	-1,156	-603	413	118	-1,228
	Cumulative % of planned (Gross)	4%	50%	264%	N/A	54%
Installed Energy Savings (kWh/year)	Total Gross Deemed Savings	72,449	282,170	317,574	63,092	735,286
	Realization Rate Adjustment (78%)[25]	4,854	-63,206	-71,137	-14,133	-143,621
	Adjusted Gross Savings	77,303	218,964	246,438	48,960	591,665
	Net-to-Gross Adjustment (45%)[26]	-11,595	-120,211	-135,294	-26,879	-293,980
	Net Adjusted Savings	65,708	98,753	111,143	22,081	297,685
	Planned Savings (Net)	1,038,000	1,038,000	49,858	0	2,125,858
	Cum. % Toward Planned Savings (Net)	6%	10%	223%	N/A	14%

[25] Realization rate adjustment for 2012-2014 was 107%. Starting in 2015, the realization rate adjustment was updated to 77.6% based on the 2015 Load Shape Study.

[26] NTG adjustment for 2012-2014 was 85% per the program planning assumptions. Starting in 2015, the NTG adjustment was updated to 45.1% based on the 2015 Net-to-Gross Characterization Study.

Category	Item	North Carolina				
		2014	2015	2016	2017	Program Total (2014-2017)
	Avg. Savings per Participant (Gross)	1,647	473	478	535	516
	Avg. Savings per Participant (Net)	1,493	165	167	187	209
Installed Demand Reduction (kW)	Total Gross Deemed Demand	19	58	69	14	160
	Realization Rate Adjustment (89%)[27]	-3	-6	-8	-2	-19
	Adjusted Gross Demand	16	51	61	13	141
	Net-to-Gross Adjustment (45%)[28]	-2	-28	-33	-7	-71
	Net Adjusted Demand	14	23	27	6	70
	Planned Demand (Net)	348	348	18	0	714
	Cum. % Toward Planned Demand (Net)	4%	7%	153%	N/A	10%
	Avg. Demand per Participant (Gross)	0.44	0.10	0.10	0.12	0.11
	Avg. Demand per Participant (Net)	0.31	0.04	0.04	0.05	0.05
Program Performance	Cum. $Admin. per Cum. Participant (Gross)	$42	$13	$12	$21	$14
	Cum. $Admin. per Cum. kWh/year (Gross)	$0.03	$0.03	$0.03	$0.04	$0.03
	Cum. $Admin. per Cum. kW (Gross)	$96	$136	$120	$174	$128
	Cum. $EM&V per Cum. Total Costs ($)	34%	11%	7%	14%	12%
	Cum. $Rebate per Cum. Participant (Gross)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[27] Realization rate adjustment for 2012-2014 was 83%. Starting in 2015, the realization rate adjustment was updated to 88.8% based on the 2015 Load Shape Study.

[28] NTG adjustment for 2012-2014 was 85% per the program planning assumptions. Starting in 2015, the NTG adjustment was updated to 45.1% based on the 2015 Net-to-Gross Characterization Study.

Figure 4-5. NC Residential Heat Pump Upgrade Cumulative Participation Compared to Planned and Over Time

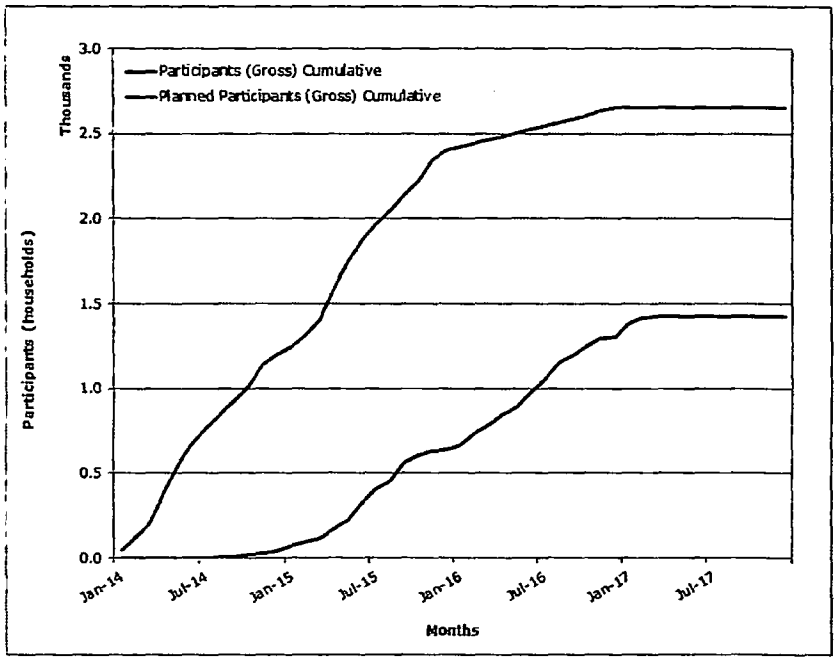
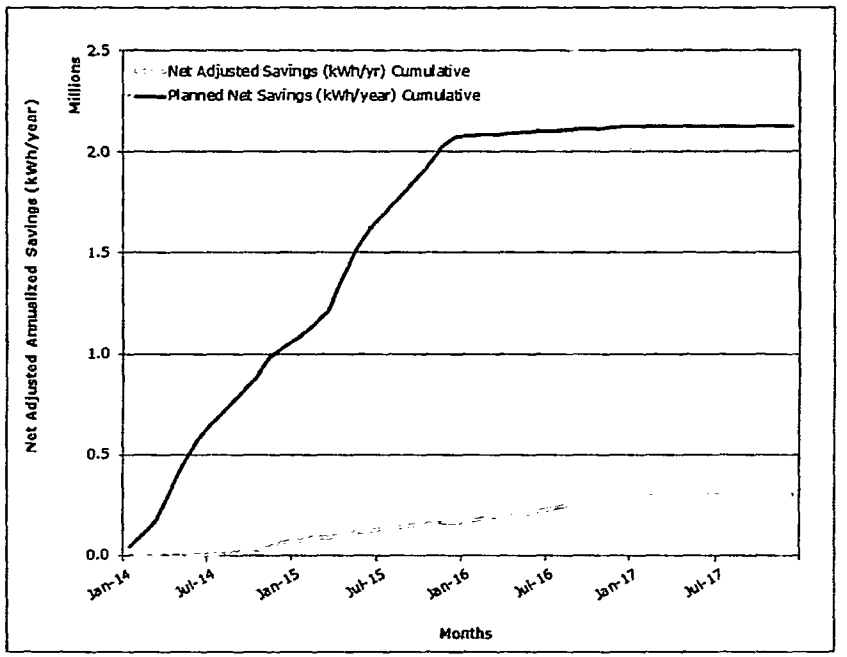


Figure 4-6. NC Residential Heat Pump Upgrade Cumulative Net Adjusted Annualized Savings (kWh/year) Compared to Planned and Over Time



In Virginia and North Carolina, while the program continued to enroll new participants every year at a steady pace, the Residential Heat Pump Upgrade program did not meet its cumulative program goals for participation incremental net energy savings or peak demand reductions in both states (Figure 4-3 and Figure 4-4 in Virginia) (Figure 4-5 and Figure 4-6 in North Carolina). The penetration goals for this program in both states were significantly greater than actuals. For this program, the average Virginia program participant saved 758 kWh/year (net) and North Carolina participant saved 209 kWh/year (net). These are lower than the initial program planned average of 856 kWh/year (Table 4-1).

Average program net savings per participant were over 1,000 kWh/year in 2012 through 2014, but decreased significantly starting in 2015 to less than 500 kWh/year. This is due to updates to the STEP Manual gross energy savings baseline assignment. In 2012 through 2014, the baseline heat pump efficiencies were based on the existing conditions rather than federal minimum requirements. During that period, the federal minimum requirement for heat pump efficiencies was 13 SEER and 7.7 HSPF, a standard that was in place since 2006. In 2015, DNV GL updated the STEP Manual calculations to assume all baseline heat pump efficiencies to be the same as the new Federal minimum requirements that came into effect (14 SEER and 8.0 HSPF for packaged systems, and 8.2 HSPF for split systems), regardless of the existing heat pump conditions.

Additionally, this approach assumed that all existing heat pumps were replaced when the equipment failed or burnt-out. For this program in particular, approximately 68% of the existing heat pump units had failed (representing 65% of gross energy savings as shown in Figure 4-9 below). Had these customers not participated in this program, they would still have been required to install a heat pump that met the Federal minimum requirements. For them, assuming a baseline heat pump efficiency consistent with the new Federal minimum requirements for estimating gross energy savings was an accurate representation of their gross energy savings.

For the approximately 32% of the existing heat pumps that were still operational at the time of replacement (early replacement), this approach yielded potentially conservative estimated gross savings. The gross energy savings for the early replacement heat pumps that were replaced sooner than the end of the existing heat pump life may be more accurately represented and calculated using the actual existing heat pump equipment efficiencies rather than the Federal minimum standard for the first few years of the new installation. However, over the course of the measure life, using the existing system efficiency would yield an overestimated gross energy savings from the heat pump replacement. In some locations, outside of Virginia and North Carolina, to more accurately estimate program savings for these situations, a dual baseline may be applied. In those cases, a measure would have two mutually exclusive estimated savings applied at different times of the equipment measure life. One would be calculated using baseline system efficiency for the existing heat pump. It would be applied in the first year that the measure was installed and every subsequent year until the assumed end of the baseline heat pump equipment life. The second estimated savings is calculated using the Federal minimum standard heat pump efficiency. That estimate is applied for all subsequent years after the end of the baseline heat pump equipment life, through the end of the measure life. However, as an EM&V policy, DNV GL does not apply dual baselines for deemed savings in the STEP Manual for any program. Therefore, it was determined that it would be most appropriate to use the Federal minimum standard as the single baseline to apply to all participating heat pumps in this program over the course of the program measure life.

Over the program life in Virginia, total program spending was 45% of planned. This was a product of discrepancies with program design from a consultant not involved with program implementation. Program

administrative costs per participant ($1,466) started high in the first year (2012) when the program was initially ramping up and had fewer participants compared to other program years. After 2012, administrative costs per participant were generally decreasing with slight fluctuation, and averaged at $35 per participant over the program life. Administrative costs per gross kWh/year averaged $0.03/kWh/year over the program life. Rebate amount per participant averaged $218 per participant.

Virginia program administrative costs per gross kWh/year saved and the rebate amount per participant both remained steady over the program life. Administrative costs per gross kW saved fluctuated over time between $85/kW and $227/kW, not accounting for the first year where the low participation makes it difficult to compare with others. The average program life administrative cost per gross kW saved was $105/kW. Lastly, EM&V costs for this program in Virginia averaged to 13% of total program costs. Part of the EM&V cost was driven by consecutive years of long-term impact evaluation metering studies. The study results were utilized in all other residential programs that had heat pump related measures. The metering evaluation results were also leveraged to meet part of the PJM EE resource verification requirements for bidding this program as an EE resource in what is now known as the Capacity Performance Market.

In North Carolina, these program spending performance indicators behaved similar to the same indicators in Virginia over time. Program administrative costs per participant averaged to $14 per participant over the program life. Average administrative costs per gross kWh/year saved and rebate amount per participant were $0.03/kWh/year and $218 per participant, respectively. These are the same as in Virginia. Average administrative costs per gross kW was $128/kW, averaged across the program life. And the EM&V costs were 12% of the total program costs.

4.1.2.2 Additional Virginia Program Participant Data

Figure 4-7 (next page) shows the distribution of the gross annual energy savings by the existing heat pump SEER values over the program life in Virginia. The majority of the energy savings was in 2013 from the replacement of existing heat pumps with 10 SEER to below SEER 11 (almost 25% of total program gross annual energy savings). In every year, existing heat pumps in this SEER range consistently accounted for the majority of that year's gross annual energy savings. In total, the existing heat pumps in this SEER range (10–10.9) produced 56% of the total program gross annual energy savings.

Figure 4-7. VA Residential Heat Pump Upgrade Program Existing Heat Pump SEER Value as % of Total Gross Annual Energy Savings (2012-2017)

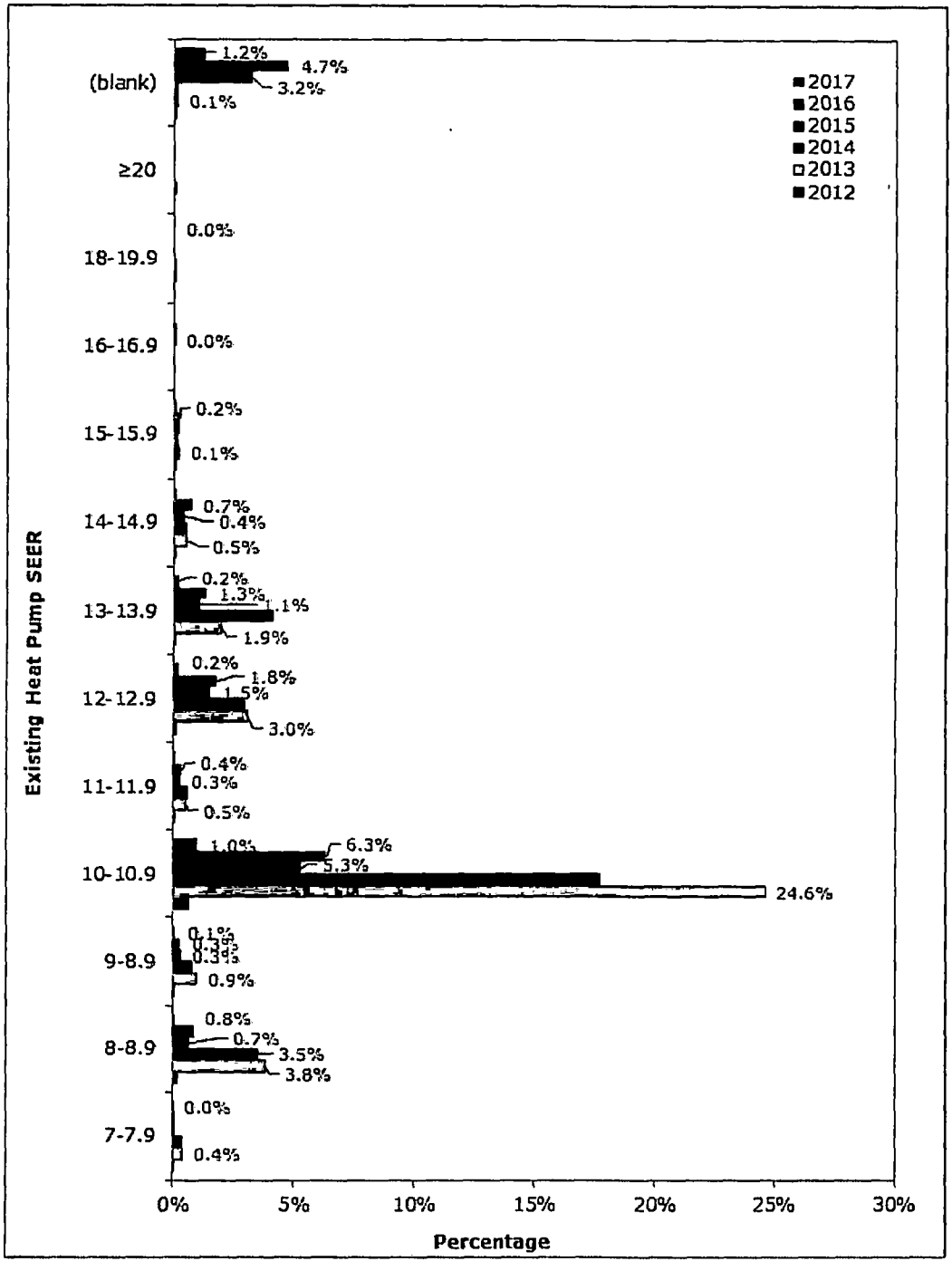


Figure 4-8 provides insight into Virginia program savings by dwelling for the entire program life (2012-2017) in Virginia. Most rebated heat pump units are installed in single-family homes (92%) and

account for the overwhelming proportion of gross energy savings (88%) and gross peak demand reduction (93%).

Figure 4-8. VA Residential Heat Pump Upgrade Program Performance Indicators by Building Type as % of Total (2012-2017)

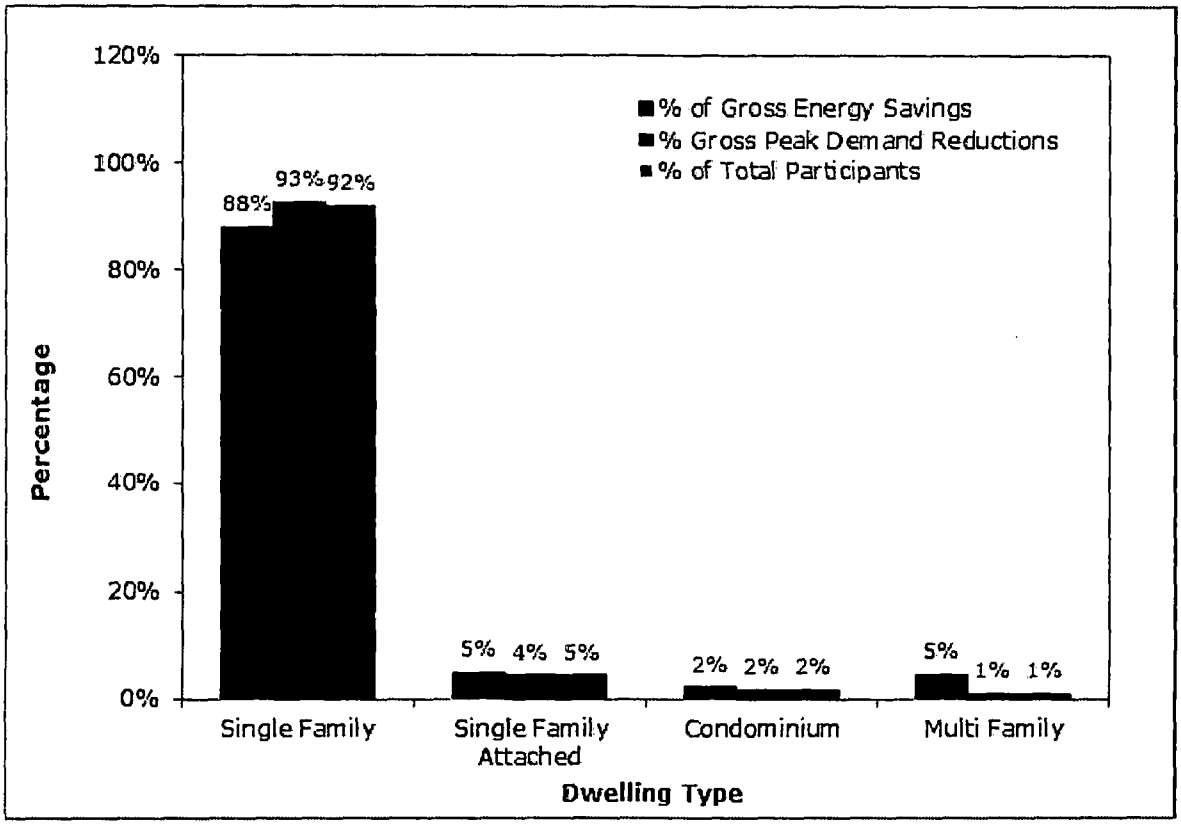
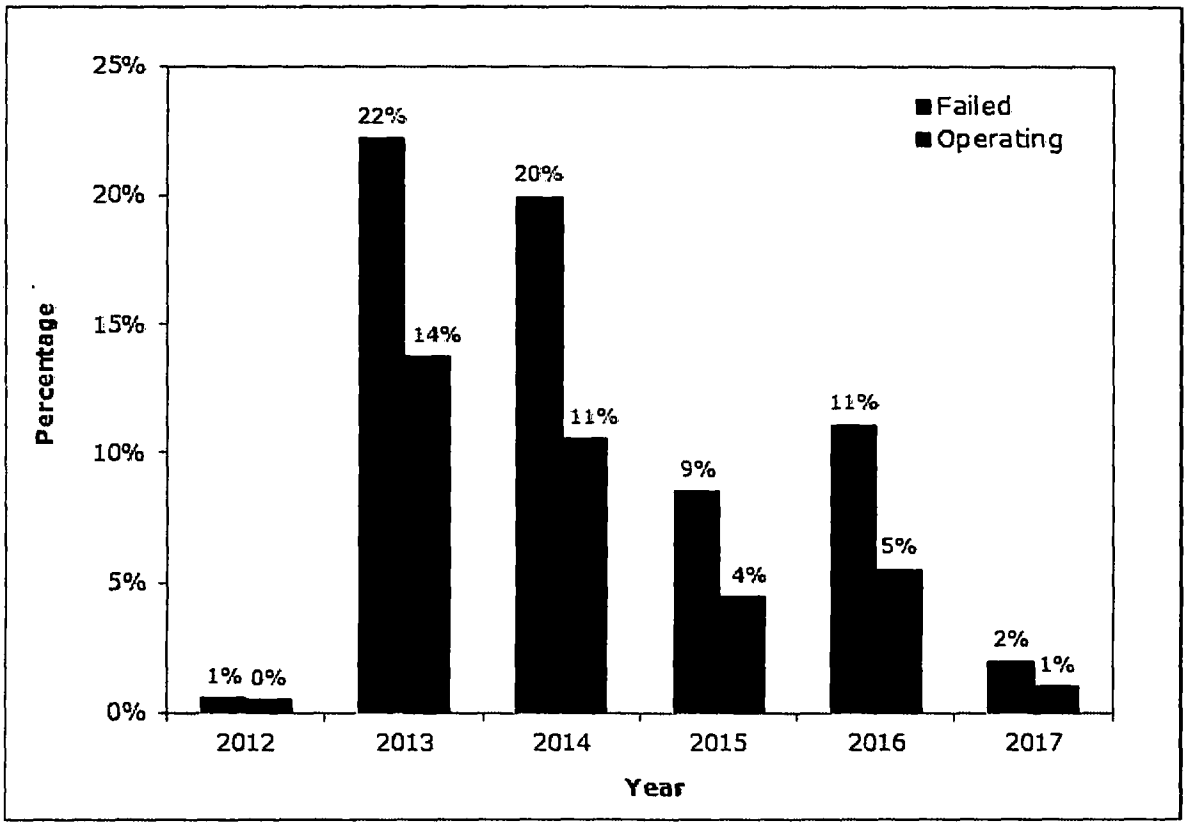


Figure 4-9 shows the condition of the replaced units each year of the program life as a percentage of gross annualized energy savings (kWh/year), whether it was an operating or failed system. Over the program life, replacement of failed systems represents the majority (approximately 65%) of gross energy savings.

Figure 4-9. VA Residential Heat Pump Upgrade Program Gross Energy Savings (kWh/year) by Condition of Replaced Unit as % of Total (2012-2017)



4.1.2.3 Additional North Carolina Program Participant Data

Figure 4-10 (next page) shows the distribution of the gross annual energy savings by the existing heat pump SEER values over the program life in North Carolina.

The majority of the energy savings was in 2016 from the replacement of existing heat pumps with 10 SEER to below SEER 11 (21% of total program gross annual energy savings). Every year, existing heat pumps in this SEER range consistently accounted for the majority of that year's gross annual energy savings, similar to program results in Virginia.

In total, the existing heat pumps in this SEER range produced 53% of the total program gross annual energy savings, again similar to the program results in Virginia.

Figure 4-10. NC Residential Heat Pump Upgrade Program Existing Heat Pump SEER Value as % of Total Gross Annual Energy Savings (2014-2017)

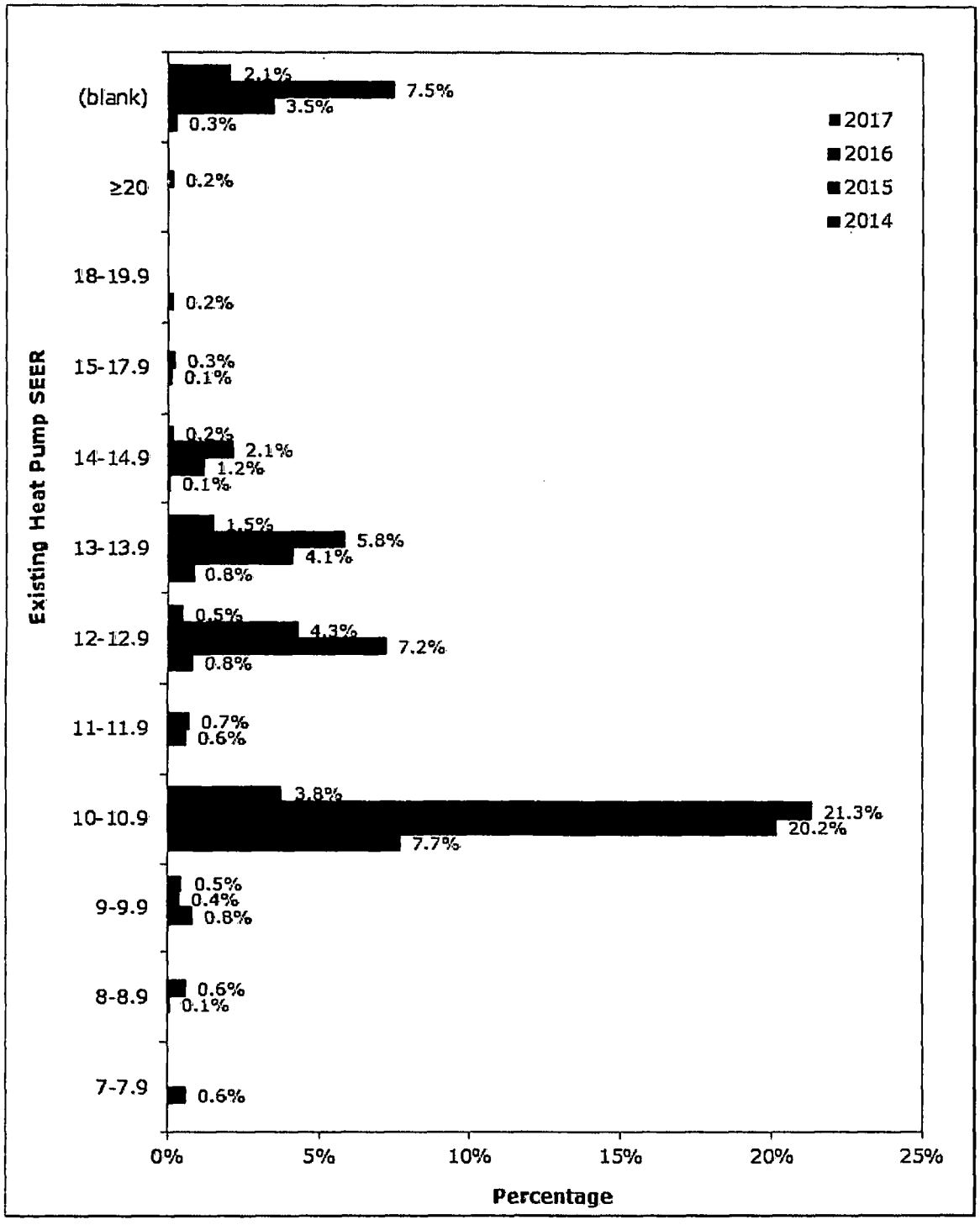
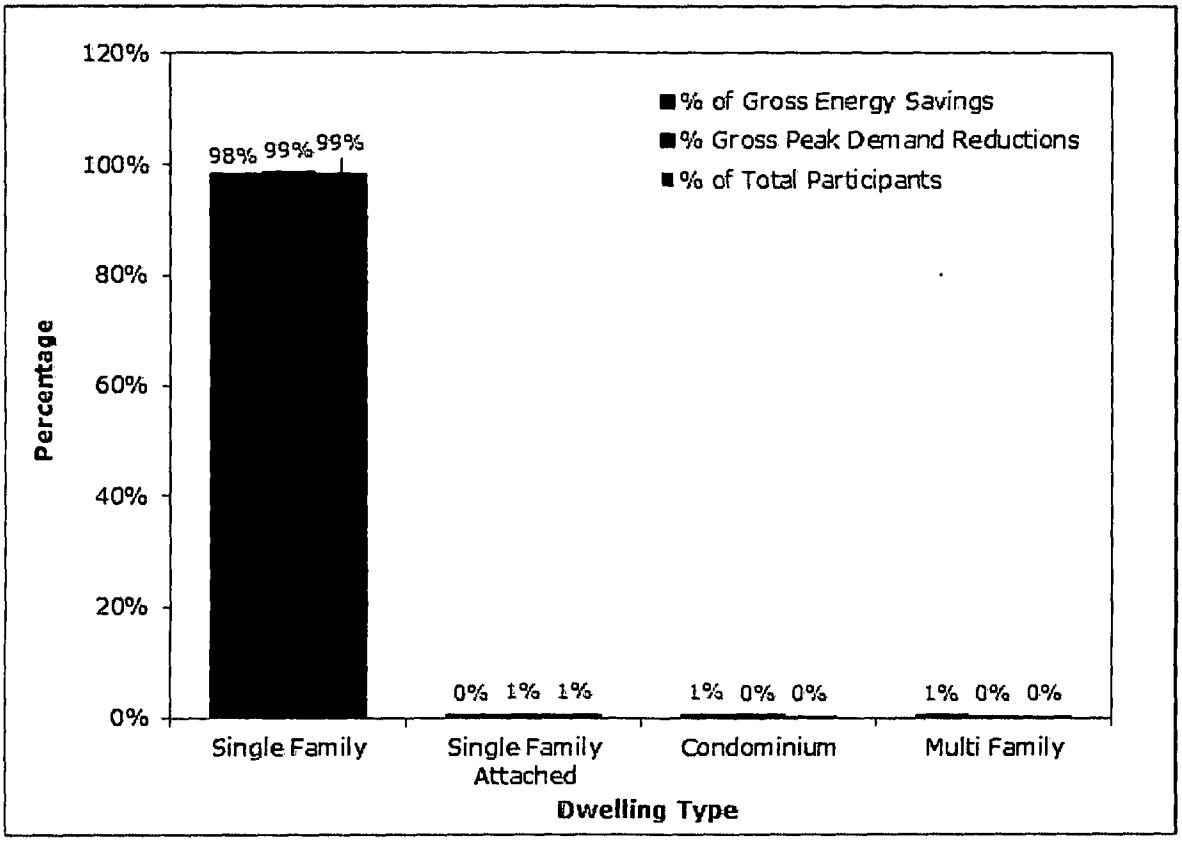


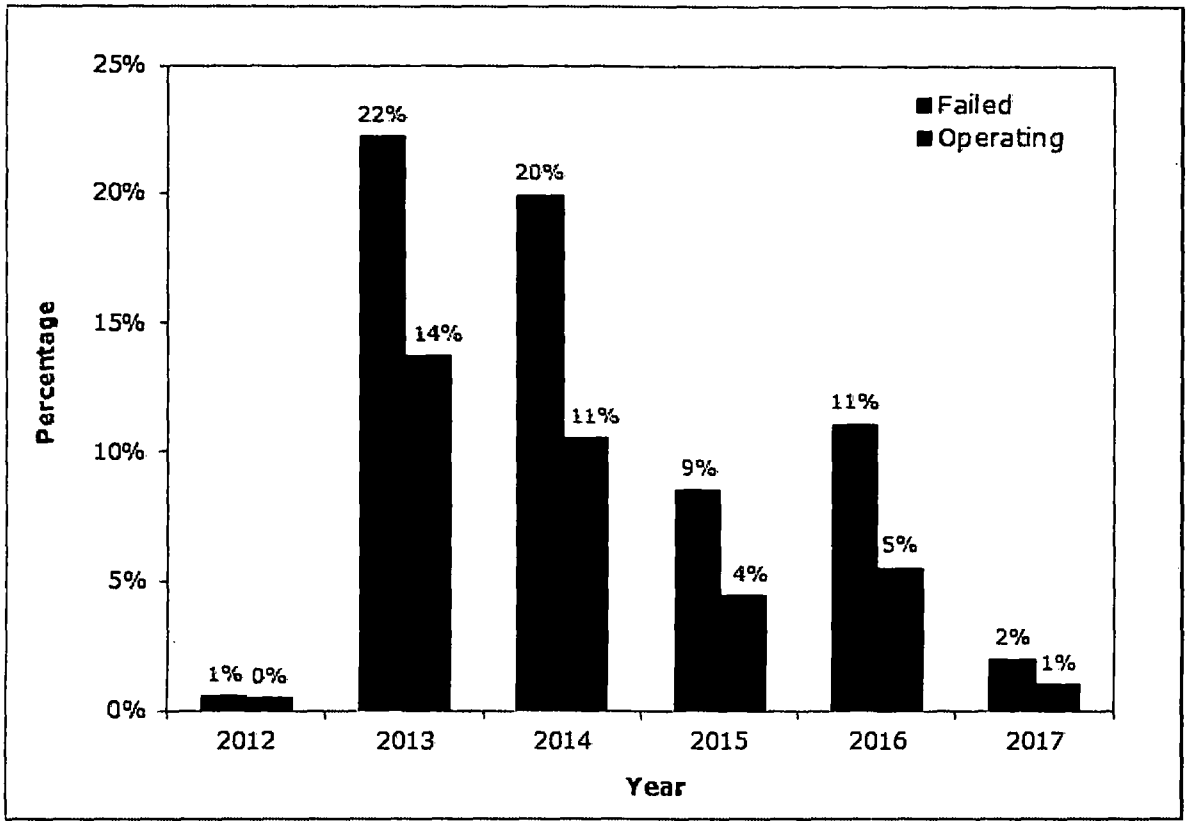
Figure 4-11 provides insight into North Carolina program savings by dwelling type and system condition. Most rebated heat pump units are installed in single-family detached homes (99%) and account for the overwhelming proportion of gross energy savings (98%) and gross demand reduction (99%).

Figure 4-11. NC Residential Heat Pump Upgrade Program Performance Indicators by Dwelling Type as % of Total (2014-2017)



Similar to Virginia, the majority (approximately 65%) of the gross annualized energy savings of replaced heat pumps failed prior to being replaced (Figure 4-12) in North Carolina.

Figure 4-12. NC Residential Heat Pump Upgrade Program Gross Energy Savings (kWh/year) by Condition of Replaced Unit as % of Total (2014-2017)



4.2 Residential Heat Pump Tune-up – Virginia and North Carolina

The Residential Heat Pump Tune-Up Program provides qualifying residential customers with an incentive to have a participating contractor tune-up their existing heat pumps once every five years to achieve maximum operational performance. Participant enrollment began in August 2012 in Virginia and January 2014 in North Carolina. The Residential Heat Pump Tune-Up Program follows the same eligibility guidelines in both states.

A properly tuned system should increase efficiency, reduce operating costs, and prevent premature equipment failures. Customers are eligible for one tune-up per heat pump during the five-year program time period. Existing units must be in operation for at least six months to be eligible for the tune-up rebate. Units must be in working order prior to and after tune-up. To be eligible for the program, customers must live in a

single-family residence, apartment, condominium, or manufactured home with electric heating and cooling, and must own the home or be able to obtain permission from the owner to perform the repairs or improvements recommended. Homes with gas- or oil-fired supplementary heat do not qualify.

This program is implemented through a contractor network, so customers must contact a participating contractor to be eligible for the rebate. Customers are not considered participants until a completed application form is processed and a rebate is issued. This process can take several months, as customers have 45 days to submit their rebate application and the Company has 90 days to process it.

The contractor must verify that it performed the following functions before administering the rebate:

- Thermostat has been checked for proper operation
- Air filter has been inspected
- Condensate drain has been inspected
- Evaporator coil has been inspected
- Evaporator fan and motor have been inspected
- All accessible refrigerant lines have been inspected
- Condenser coil has been inspected
- Condenser fan motor has been inspected
- Checked system for proper refrigerant charge level

Over the program life, slightly over half (54%) of all tune-ups in Virginia and North Carolina were rebated to the contractor directly, with customer permission. When this occurred, the contractor had to demonstrate that the customer was provided the rebate benefit on their invoice to the customer. This allowed for an "instant" rebate for the customer without having to wait multiple weeks for a check to arrive via the standard rebate process. Table 4-4 provides a breakdown of the percent of rebated tune-ups given directly to contractors by state. Compared to other residential programs that offer this option to customers, this program has the lowest percentage of rebates issued to contractors directly.

Table 4-4. Percent of 2012-2017 Residential Heat Pump Tune-Up Program Tune-Ups Rebated to Contractors Directly

State	Percent of Heat Pump Tune-Ups Rebated	Percent of Rebates Given to Contractor
VA	94%	57%
NC	6%	10%
Total	**100%**	**54%**

In 2016, Dominion Energy announced the program closed to new participants in both states. To be eligible for a rebate, the service must have been completed by a participating contractor by December 24, 2016 and rebate applications received by February 7, 2017. This report section shows those final enrollments of 2017. The rebate form submission and processing time all together can add up to 135 days before a participant shows up in the tracking and reporting system. This report section shows those final enrollments in 2017 that were serviced in the last months of 2016.

4.2.1 Methods for the Current Reporting Period

For the current period, the approach included reviewing the tracking data and estimating gross energy and peak demand savings using STEP Manual calculations with the estimated realization rate from the 2014 billing analysis.

Table 4-5 outlines Dominion Energy's initial program planning assumptions that were used to design the program.

Table 4-5. Residential Heat Pump Tune-Up Program Planning Assumptions System-wide

Item	Description
Target Market	Residential customers with eligible HVAC systems
NTG Factor	90%
Measure Life	5 years
Average Energy Savings (kWh) per Participant per Year	762 kWh per participant per year
Average Peak Demand Reduction (kW) per Participant	0.23 kW per participant per year
Average Rebate (US $) per Participant	$90 per participant

4.2.2 Assessment of Program Progress Towards Plan

The next section describes the program's progress towards planned participants, energy savings, and peak demand reductions.

4.2.2.1 Key Virginia and North Carolina Program Data

Table 4-6, Figure 4-13, and Figure 4-14 on the next pages summarize key indicators of progress over time from August 2012 to December 31, 2017 for Virginia.

Following that, Table 4-7, Figure 4-15, and Figure 4-16 summarize key indicators of progress over time from January 2014 to December 31, 2017 for North Carolina.

Detailed monthly program indicators for Virginia are provided in Appendix A.2 and for North Carolina in Appendix B.2.